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PAPERS

ON SUBJECTS CONNECTED WITH

THE DUTIES

OF THE

CORPS OF ROYAL ENGINEERS.

CONTRIBUTED BY OFFICERS OF THE ROYAL ENGINEERS
AND
HON. EAST INDIA COMPANY'S ENGINEERS.

NEW SERIES.
VOL. VI.

PRINTED BY W. P. JACKSON, WOOLWICH.

1857.

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PREFACE.

It was expected that the journals of the siege of Sebastopol would have appeared in this volume, but the Secretary of State for the War Department has ordered them to be printed separately; the first Paper however contains the principal results of the experience gained in executing the laborious works which were required there to overcome the almost inexhaustible resources of its defenders, and the accompanying observations on the subject by Sir Harry Jones will be found most valuable as a guide in future sieges.

The Paper on the Troops and "matériel" sent to the Crimea shews the extent of the military resources lately developed by France; and officers of Engineers will feel an increased interest in its perusal when they reflect that at two critical periods the organization of her forces has been confided to officers of the Corps du Génie, viz. to Carnot at the beginning of the present century, and now to Marshal Vaillant.

The long struggle between the immense masses of troops arrayed on both sides in the Crimea forms a remarkable contrast to the decisive success of a small body of Turkish troops in fortifying and defending the Arab Tabia near Silistria against a large invading army, and to the repulse of the Russians at Kars by similar means, described in two of the Papers in this volume.

In both these cases success has been principally attributed to the energy of a few British officers who were present; and the histories of all three memorable defences unite in impressing, not only on the Engineer, but on every soldier, the importance of a good use of intrenching tools, and of a knowledge of the best modes of employing military workmen, so as to enable undisciplined, as well as disciplined, troops to resist greater numbers of assailants, or to prepare the way for an assault of a strongly fortified position, since without these the best Artillery, Cavalry and Infantry have often found themselves incapable of making either a successful attack or defence.

P. J. BAINBRIGGE,

Lieutenant-Colonel Royal Engineers.

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PROFESSIONAL PAPERS.

PAPER I.

Report of the Siege Record Board, on the Works Constructed before Sebastopol;

made by order of

LIEUT. GENERAL SIR HARRY JONES, K.C.B.,

Commanding the Royal Engineers

and accompanied by his observations.

Brigade Orders for the Assembly of the Board.

Head Quarters before Sebastopol,
August 31*st*, 1855.

The Lieut. General Commanding, considering it highly important that the Journal of the Siege should be accompanied by a Report on the mode of construction of the different works, and as many of the Directors have been either killed or wounded, and the benefit of their opinions lost, directs therefore that a Board shall be formed, composed of the two Directors of the two attacks and Captain Ewart, who has already collected detailed information. The objects to be attended to are—the original construction of the batteries, parallels and approaches, and the alterations which may have been made in them; all revetting materials, platforms, splinter-proofs, magazines, intrenching and other tools; in fact, every thing connected with the operations which relates to the Engineer Department. Dimensions, scantlings and weights should be given in all cases, and neat diagrams made on a half-sheet of foolscap, or a plain outline drawing with figured dimensions marked on it, with letters of reference to elucidate the report. Lieutenant Colonel Chapman will furnish one or more officers to make these drawings on the application of the Board.

The Board should meet at least once a week for this purpose, and they will call on any officer or non commissioned officer they may think desirable for such information as they may require on the subjects before them, the great object being to furnish a full, accurate, and detailed account of all subjects connected with the siege.

The Lieut. General trusts to the hearty concurrence and zeal of the Board, in carrying out this arduous but very important duty, and requests that the Board will send him, at the end of every month, a memorandum of the subjects they have had under consideration, and of those they have completed.

Lieutenant Colonel Chapman will, from time to time, examine the proceedings of the Board, and assist them with his opinion and advice when he may consider it necessary.

By order,

(Signed) E. F. BOURCHIER, Brigade Major, R.E.

PROCEEDINGS OF THE SIEGE RECORD BOARD.

FIRST MEETING.

3rd September, 1855.

President .. MAJOR BENT, Director, Left Attack.

Members { CAPTAIN COOKE, Director, Right Attack.
CAPTAIN EWART, Acting Adjutant, in charge of Park.

The Board having assembled in pursuance of the orders of the Commanding Royal Engineer, dated 31st ult., resolve that their proceedings at each meeting shall be recorded in a book, and that their meetings shall take place every morning at 12 o'clock.

The Board proceeds to consider the most advisable course to adopt, with the view of carrying out the instructions detailed in the order above referred to.

Their duty appears to resolve itself into the consideration of subjects under the following heads:—

1st.—Construction of works, illustrated by plans and sections of those most approved from results of practice.

2nd.—Materials; description, how and where obtained; nature and remarks.

3rd.—Superintendence and labour.

4th.—Tools, &c., &c.

It was agreed to endeavour before the next meeting to collect information respecting the original construction of the batteries.

SECOND MEETING AND CONTINUATION.

September 12*th*, 1855.

Present { MAJOR BENT,
CAPTAIN COOKE,
CAPTAIN EWART.

In consequence of the bombardment and assault upon the works of the enemy, the Board have not been able to collect fully the memoranda respecting the original construction of the batteries, but the following are ordered to be entered upon the minutes.

The batteries for the siege which were prepared for the first bombardment in October, 1854, were as follows, viz.:—

Right Lancaster, in advance, and to the right of the present Victoria Redoubt.

Gordon's, or 21 gun battery, now first parallel of right attack, on Frenchman's Hill.

Left Lancaster Battery, below and to the left of the Picket-house on the Woronzoff Road.

Chapman's, or 24 gun battery, now first parallel of left attack, on Green Hill.

The nature of the soil in each case was very similar, being a stiff strong clay, overlying the Oolitic formation, with the rock frequently cropping out on the surface.

These batteries were commenced at ranges varying from 1,200 to 2,300 yards from the works of the enemy, who however possessed such a powerful artillery, capable of being brought to bear upon them, that the question of obtaining good cover upon the night of breaking ground was a most important one.

Under these circumstances then, it was considered that each work should be commenced as an ordinary trench, that is, by extending a certain number of men at such intervals apart as would enable them to use their tools, the earth excavated being thrown into gabions placed by them, and to their fronts, to form the parapet of the future battery.

To increase however the amount of cover thus to be gained, a similarly extended line of excavators was placed outside, at such a distance as would allow for a sufficient thickness of parapet, (at first 24 feet.)

Figures 9 and 10, Plate 1, shew sections of the Parapets of Batteries; the revetments used were chiefly gabions in two courses, with a row of fascines between them, and crowned with one or two rows of sand bags; (see Figure 9). The earth was obtained from a ditch in front, or by levelling the terreplein; but was frequently carried in baskets from whence it could be most easily obtained, when the ground was very rocky.

In some instances the men were extended along these lines by files instead of by ranks, the front rank man having a pick and the rear rank man having a shovel.

This plan was always adopted with working parties from the Turkish regiments attached to the Corps.

The parapets were thus carried up to a height of 6, 7, or 8 feet, solid, and the platforms laid: the embrasures were sapped out and revetted from the interior, remaining blinded until the night before fire was opened.

The tracing of the works was performed in the usual way adopted for parallels by the Officers of Engineers, assisted by the Royal Sappers and Miners.

The operations of the working parties were protected by covering parties thrown well out in front; that for Green Hill was commanded by a Brigadier General, and that for Frenchman's Hill by a Colonel or Lieut. Colonel. The greatest number in a working party was at Green Hill, where as many as 1,200 men were sometimes required.

Before being armed, traverses were added to the large batteries, which were constructed on the left attack principally of sandbags, and on the right attack of gabions and fascines; they were made on the left attack of great thickness (some 14 feet at base) as they were not merely required to be splinter proof, but to protect the batteries from oblique fire, in some instances amounting very nearly to enfilade.

Those in the right attack were at first made merely splinter-proof (3 gabions thick at base), but were afterwards rebuilt of similar thickness to those on the left attack.

The magazines, the construction of which will be hereafter entered upon, were at first placed under cover of, but separated from the parapet by a narrow passage, so that the entrance was covered by the former. Afterwards they were in some cases placed against the parapet, but the course adopted in this particular was generally the result of the position, and more especially depended upon the nature of the soil in the reverse of the trenches.

Disadvantage was found to arise in some of the early batteries from the embrasures being made oblique, instead of the parapets being indented, which rendered the merlons so weak that they would not stand against the enemy's fire.

In constructing an indented battery, it was found to be of the utmost importance not to deviate from General Pasley's rule, " that the embrasure should not be in the centre of the indent, but one-third of the distance from the angle cut off." It was also found by experience with those batteries which were first constructed, that the size of the embrasures was not sufficient for the large natures of ordnance, which require wide embrasures, and therefore the strength of the merlons was diminished. The naval brigade also complained that they had not room to work the heavy guns.

In consequence of the above, in the batteries constructed in the spring, orders were given to make the parapets thicker, and the distance from centre to cent 21 feet, for all natures of ordnance; but this not proving sufficient for guns heavier than 24-pounders, it was ordered that two guns should occupy the space hitherto allotted for three. Latterly, therefore, 27 feet was the distance allowed from centre to centre of embrasures. In cases where the nature of the ground admitted of it, the batteries were made sunken or half-sunken in preference to elevated.

Mortar Platforms.

In taking up mortar platforms, it has been observed that those which had 6 sleepers of fir (10 inches by 8 inches) have sunk considerably in the middle, but those which have a seventh, or central one, stood well. The deal planks of platforms rapidly required renewal, while those of teak, or harder wood, stood well: some of the latter have lasted for six months, while the former required to be renewed twice in the same time.

For a 13-inch mortar two transverse sleepers were found to be sufficient, provided they were carefully laid, and the ground well drained; in localities where good drainage had not been secured three, or even four, were found necessary.

The sleepers which were 14 inches by 7 inches, have been found to break in the middle, and those which were square (13 inches by 13 inches) have stood well.

The result of experience with 13-inch mortar platforms appears to be that the transverse sleepers should be two[*] in number, 12 inches or 13 inches square, if of fir, or 10 inches square, if of harder wood; that the longitudinal sleepers should be six in number, if of the same dimensions as the transverse, and increased in number if of less dimensions, and that the tops should be of seasoned oak planks, or other hard wood, not less than 3½ inches thick, and 8 inches broad.

The dimensions adopted for 13-inch mortar platforms were 10 feet by 10 feet, for land service, and for sea service 12 feet long by 10 feet wide. The latter were not found to be large enough; 12 feet by 12 feet is the least that should be adopted. When timber 12 feet long could not be obtained, shorter pieces were scarfed and bolted together; this was found not to answer, as they invariably give way at the scarfs. The tops were fastened down by 8-inch spikes, five-eighths of an inch square.

The platforms shewn in Figures 5 and 6, Pl. 2, were used for both 10-inch and 13-inch mortars; the transverse sleepers were 10 inches by 8 inches, and the longitudinal ones 8 inches by 8 inches, and they were covered with deal 4 inches by 4 inches, or 4 inches by 9 inches, as the timber could be procured. The deal coverings wear very rapidly, and 4" planks were found to be much too narrow for covering any description of mortar platforms.

For the sea service 13-inch mortar platforms, 4 transverse sleepers, 12 inches by 12 inches, and six longitudinal ones, also 12 inches by 12 inches, were found necessary; ribands of oak, 4½ inches by 3 inches, were laid on each side, and bolted down to the transverse sleepers; these were found to answer when the platform was perfectly firm, but when there was any sinking of the sleepers from imperfect drainage, or other causes, the play of the planks, when the mortar was fired, broke the ribands immediately: the bolts were of one-eighth of an inch round iron.

For 10-inch mortar platforms, the following dimensions were adopted, and were found to be sufficient where the battery was well drained; six longitudinal sleepers, 10 inches by 10 inches, of fir, covered by oak planks, 8 inches wide and 3½ inches deep. Spikes the same as for 13-inch mortars. (Size of platforms, 10 feet by 10 feet.)

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[*] "I have observed that in all cases where *two* only have been used, the platforms have sunk in the middle, and am of opinion that less than three transverse sleepers should never be used."—F. L. Chapman, Lieut. Colonel, R.E.

For 10-inch mortars no transverse sleepers were considered requisite, and they were only placed when it was foreseen that the 10 inch would be replaced by 13-inch mortars. Deal planking, 5 inches by 3 inches, of Alderson's pattern, made in England, although not so durable as the oak planking, was found to last well enough to warrant its use.

Eight-inch mortars were not much used: they were worked on platforms consisting of six longitudinal sleepers, 10 inches by 10 inches, covered with planking of Alderson's pattern.*

Gun Platforms.

Alderson's.—Too much praise cannot be given to these platforms, they were used of the dimensions laid down in the British Aide-Memoire (with the exception that they were 10 feet wide, instead of 9 feet), for 24 and 32-pounders, and 8 inch guns of 65 cwt., and answered well.

On the right attack the Director (Colonel Tylden) increased the number of sleepers to eight, and had the tops fastened down by 6-inch spikes (three to each plank). 8-inch guns on travelling carriages were mounted on these, and they answered excellently. This was not adopted on the left attack, but the same object was attained by ribands on each side, spiked down to the sleepers.

In the early part of the siege, platforms of teak, prepared at Woolwich, were used for 24-pounders: they were of the Madras pattern, with the main difference that they would not traverse, and they were therefore given up as useless.

The travelling carriages were subsequently always worked on rectangular platforms of the same dimensions as for the ship carriages. The platforms were prolonged by earthen ramps, 4 or 5 feet in length, to receive the trail when recoiled. This was found to answer very well.

For 10-inch guns and 68-pounders, of 95 cwt., the platforms were of the same dimensions as for 32-pounders and 8-inch guns of 65 cwt., with the exception that the scantling of the sleepers was increased to 6 inches by 6 inches.

The soil in which the platforms were laid is a marly clay, which turns very rapidly into mud. It was found that where the drainage was not perfectly efficient, the mortar platforms of the strength above given would not stand for any time, in consequence of the soil turning into mud, and causing a sinkage of the sleepers.

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* NOTE BY THE EDITOR.—It may be useful to remark here, as a guide in cases where small scantling only is procurable, that a mortar platform *consisting only of fir baulks, 4 inches by* 3½ *inches*, and 10 feet long, was tried in the soft ground in the marshes at Woolwich by the Ordnance Select Committee in 1846, at my suggestion, and that they were well satisfied with it, having fired about 15 rounds from it with a 13-inch mortar at 75° elevation, and at a range of 1,100 yards.

It was thus constructed: two sets of 4 baulks each were laid in two trenches parallel to the line of fire, and so that each set should be under one cheek of the mortar bed: over these a complete floor of baulks was laid transversely, and another above all longitudinally, the upper baulks being connected by 5 sets of ¾-inch iron pins of different lengths, running through 5 equi-distant holes bored through each: The upper layer was kept firm by a baulk on each side of it, placed on edge and pinned down to the lower layer, and also by others fixed along the rear.

The mortar bed recoiled easily, for there were no edges in the flooring to catch it, and it did not disturb these baulks, as was the case with the dowelled baulks laid transversely, in the previous experiments, described at pages 31 and 32, vol. 8, Professional Papers; and it appears probable that for firing at only 45° elevation, one floor would have been sufficient.

Wooden pins might be substituted for the iron ones, and would have the advantage over dowels of being more easily replaced; and mud may be got out of the holes bored through the baulks more easily than out of dowel-holes, when the platforms require to be re-laid.—ED.

Slide Gun Platforms.

These were used for the 10-inch and 68-pounders as well as for Lancaster guns; they were made, from first to last, of the same dimensions as shewn in Fig. 1. Pl. 2, and answered very well. The five sleepers were latterly made of fir, which was found to answer as well as oak.

For the very heavy guns, the fighting bolts were made of iron, 16 inches long above the hurter, and 3 inches in diameter; and for the others 4½ inches long above the hurter, and 2½ inches in diameter.

Bollards were fixed for the purpose of relieving the strain upon the fighting bolt and assisting to run the guns up. They were made of the dimensions and placed as shewn in plan. When not fixed, the gun's crews attached the breeching ropes to ring bolts in the hurters, but this was found to be objectionable as tending to lift the front of the platform.

The platform shewn in Figure 1, Plate 2, was used for a ship's slide, and has a fighting bolt in the centre of the front end of it, and a bollard with a ringbolt on each side of it. The sleepers are 5 inches by 5 inches, or 6 inches by 6 inches, according to the stuff that could be procured. The covering consists of three 2 inch oak planks at front and rear, and 1 or 2 thicknesses of deal, 3 inches by 11 inches, in the middle, at such distance as may be required for the tail of the slide, viz., for an 8-inch gun, 10 feet 6 inches from front of platform; and it is laid with a slope of from 1 in 16 to 1 in 24 to the front.

That shewn in Figure 2 was used both with and without a slide; the sleepers are 6 inches by 6 inches, or 5 inches by 5 inches, according to the material at hand, and are covered with Alderson's planking, 10 feet long; the hurter is 8 inches by 8 inches (and has 2 ring bolts and a fighting bolt, when used for a slide); this was the best description of platform used in any case for heavy guns, but not wide enough at the tail to allow the gun to traverse when an unusually wide range of fire was required, and it had then to be pieced. (See Figure 3.)

The platform shewn in Figure 4 was laid with 5 transverse sleepers, and was covered with 8 planks, 3 inches by 12 inches, spiked down, and 2 ribands, 4 inches by 4 inches, bolted down; this platform did not answer, and should not be used except in cases where timber could not be procured to make the sleepers of the length and dimensions shewn in Figures 1, 2, and 3.

Chess Platforms.

In the early part of the siege some platforms were tried for 32-pounders with transverse sleepers, instead of longitudinal, and planking laid lengthwise on them; but this method was discontinued, as it was found that the wood was ploughed up, apparently from the recoil of the gun being in the direction of the grain of the wood.

Remarks on Platforms.

In order to meet the early demand for a large number of platforms, the floors and roofs of buildings were made use of. This accounts in a great measure for there being a variety in the scantlings of timbers used in the several batteries in the early part of the siege.

At the period of the siege when platforms were moved forward from the rear to the front, the average of those found to be in a serviceable state was 80 per cent., or that 4 could be laid from 5 taken up.

Revetments.

When it was first contemplated to invade the Crimea, sap rollers, gabions, fascines, and pickets were prepared in the neighbourhood of Varna by working parties from the different Divisions, superintended by the officers of Engineers assisted by the detachments of Royal Sappers and Miners attached to those Divisions. The system of working by the piece was adopted, and the prices paid were, 14d. per gabion of two feet in diameter, and 7d. per fascine of 18 feet long.

The gabions and fascines were brought into the depôt, near the place of embarkation at Varna, by the reserve ammunition horses of Divisions, each horse or mule carrying two gabions; three were tried, but it was found to be difficult to pack them so that they should not be kicked off.

When the embarkation took place, three ships were allotted for the Engineer service, and were filled up with an assortment of such tools, stores, and materials as was considered would be immediately required, including a large portion of gabions and fascines. The remainder were distributed among the different transports, generally speaking in small numbers, (40 or 50).

The arrangement of having special ships for the Engineer service is strongly to be recommended, as it was found that the stores in these were quickly landed and were immediately available, whilst it took a long time to collect those which were distributed among the other transports.

The gabions and fascines, having been landed at Balaklava, were carried to the Royal Engineer parks at the front (6 to 8 miles) in the arabas, or on the pack mules, which had been attached to the different companies of sappers.

The Artillery assisted by bringing gabions with the siege guns, the muzzles being slipped through the gabions.

The Commissariat means of transport were too limited to be of any great assistance to the Royal Engineer service.

Gabions and fascines were made in the early part of the siege, of the brushwood growing in the ravines bordering on the Attacks, and on the Heights of Inkermann, but this source of supply was soon exhausted, in consequence of the consumption at the same time of the wood for fuel for the troops; a limited supply was obtained during the spring and early part of the summer, from the brushwood growing on the hills near the Monastery of St. George. During the latter part of the siege, when the Allies occupied the line of the Tchernaya, a supply of excellent gabions was obtained from the Sardinian troops, and also from a detachment of the line stationed there for the purpose; 200 men of her Majesty's regiments, at the piece work price, supplied 600 gabions per week.

The wooden gabions made in the first instance were of the size ordinarily used in the British service, viz., 2 feet in diameter, and 2′ 9″ high in the web; subsequently larger ones were made for revetting the cheeks of the embrasures, 2′ 6″ in diameter, and 3′ 9″ high, which were found, for this purpose, to be a great improvement; a larger size still was tried (being made on the pattern of some found in the Russian works), but they were of an inconvenient size to be carried through the trenches, and it was found that they were too large to be carried or filled by a working party in the limited time of a night relief.

The fascines were made in the usual manner, 18 feet, 9 feet, or 6 feet long, and 9″ diameter, they were bound,—

1st. with gads,	3rd. with strips of hide,
2nd. ,, rope yarn,	4th. ,, iron bands,

obtained from the Commissariat off the old casks and trusses of compressed hay; the latter plan was found to be decidedly the best, and quite superseded the other three.

The large accumulation of hoop iron and hay bands suggested the idea of making gabions with them, the pickets being of deal, sawn out for the purpose, in consequence of the scarcity of green wood. The iron bands were woven in, the same as the rods of the wooden gabions, in the manner called "randing;" the ends being either turned in or bent round a picket; the last plan was found to be by far the best; iron bands were also used instead of withes for binding the gabions. These gabions were made in the Royal Engineer Park, or at Balaklava, by permanent detachments of the line, and when working by task work the day's work for three men was fixed at four gabions, which they usually completed in 6½ hours.

The advantages of iron gabions were found to be,—

1st. Their durability, a point of importance in so long a siege.

2nd. That when rendered unserviceable by the destruction of the pickets, the iron bands were collected, taken to the park, and re-made.

3rd. That they cannot easily be destroyed by fire.

It may also be remarked that iron gabions are not heavier than wooden ones of the same size, and that, in the case of a protracted siege, the materials can be easily carried, and worked up after landing.

For repairing cheeks of embrasures, an experiment was made with hurdles of wood and iron, of sizes as per table annexed, but the use of them was discontinued, as it was found that as soon as (by concussion) they became loosened from the merlon, they were quickly blown away.

The same remark applies to the revetting of embrasures with fascines.

Fascines were considered of value for crowning revetments of parapets, merlons, and traverses; those most used were 9 feet long.

The great extent of the batteries and magazines constructed and maintained during so long a siege, as well as the extent of cover required for sharpshooters in the advanced trenches or screens, caused a very great consumption of sandbags, which, throughout the siege, were of the same size as is usual in the British service; they were of common canvass (untarred) and were found to be very perishable.

The great value of sandbags consisted in their enabling the working parties to repair embrasures during the night, and the Sappers to effect hasty repairs under fire, the bags being in each case ready filled, in rear of the batteries; they were used also in stony soil for covering the tops of the parapets, in order to diminish the danger from splinters or driven stones.

When saps had to be carried over ground where there was little depth of soil, sandbags (filled during the day at convenient places) were thrown or emptied into the gabions as they were placed.

Parapets were also revetted with barrels of various sizes obtained from the Commissariat, and the ordinary powder barrels, after being emptied by the Royal Artillery. These, when not exposed to the direct fire of the enemy, were found to be excellent substitutes for gabions.

Bread bags, coal sacks, and biscuit bags, filled with earth, were also of great use in the repair of embrasures, for improving cover, and forming loopholes; but, being heavy when filled, and therefore unwieldy, they can only be considered as indifferent substitutes for sandbags.

The largest sized bag which, when filled with earth, could be carried ordinarily by one man, was 3′ long by 2′ 4″ broad, when unfilled.

Banquettes being generally formed after the parapets, were therefore constructed of made earth, or debris of rock; they were revetted with dry stone, and in some instances with old plank and fascines, secured by pickets.

The accompanying sketches (Plate 3) shew different methods which were adopted for revetting parapets of parallels and approaches.

Figs 1 to 8 shew sections through various parts of the parallels and approaches, with the revetments used; the trenches varied in width from 4 to 14 feet, and in depth from 1 to 4 feet, according to the nature of the ground, the revetments were chiefly of gabions crowned with sandbags, but powder barrels were often used to obtain additional cover; stone walls (2 feet thick), backed by earth, and beef and pork barrels, obtained from the Commissariat, were also used as revetments. Earth had to be carried in baskets in many instances, from wherever it could be procured, to obtain sufficient thickness of parapet for the purposes required.

Embrasures.

In the early part of the siege the embrasures were made 2 feet wide at the neck, (as laid down in Pasley's Rules); but at the first general repair of the batteries, it was deemed absolutely necessary to give greater width, viz., 2 feet 6 inches, and afterwards they were still further increased for heavy guns; and at the latter part of the siege they were made as follows:—

Heavy 32 prs.	2 feet	6 inches.	
8-inch gun	2 „	9 „	
10-inch gun	3 „	0 „	
Lancaster gun and 68 prs.........	3 „	3 „	

The splay of the embrasures was always regulated by the range of fire required.

The embrasures were generally made sloping, but a few countersloping ones were made for ricochet fire.

The cheeks of the embrasures were generally revetted with gabions, crowned with sandbags, which was found to be the best revetment for the purpose; when the gabions were crowned with fascines the latter were soon blown away, and if a fascine picketed down was struck by a shot the whole cheek was injured.

It was found that, from the feeble nature of the soil, the angle-gabions of the embrasures were, during one day's firing, invariably emptied of the earth by the concussion of the firing, which shook it out; this was remedied by filling these gabions with filled sandbags.

When gabions were scarce, five were used in each cheek, but as it was found that the earth at the mouth fell down and choked the embrasure, the number was increased to seven, which partially remedied the evil, but it required nine gabions effectually to do so in the case of a parapet 24 feet thick at the top, which thickness was found to be requisite in the advanced batteries opposed to those of the enemy armed with 56 or 68 prs.

Traverses.

The construction of the traverses which were made in the early part of the siege has been already described, and no material alteration subsequently took place; in some cases the traverses were detached, a passage 3 feet wide being left between them and the parapet; in other cases they were attached, the advantage of the former plan being that it enabled the gunners more readily to obtain cover when a shell burst between the traverses, and the object of the latter being to strengthen the merlons.

Small parados traverses were placed in two batteries to protect the gunners from splinters of shells bursting in rear, they were made 4 or 5 feet high, and thick enough to be splinter-proof (about 6 feet).

MAGAZINES.

In the first instance the magazines were usually placed in rear of the battery, and, where the slope of the hill admitted of it, at such a distance from the parapet as would secure their being defiladed from shot just clearing the interior crest. As a general rule the floors of the magazines were 4 feet below the surface of the ground. The walls were revetted with frames and sheeting of every dimension between 4″ × 4″ oak, and 7″ × 7″ deal. Young trees were also frequently used, but never of less dimensions than above stated. The splinter proofs were also made of such material as could be obtained, and were covered with two rows of sandbags filled with earth, and then with loose earth, until a covering not less than 7′ 6″ thick was obtained.

The triangular magazines were tried, but were not found to answer, the struts made of the timber available at the time were too weak, and bent under the downward pressure of the great weight of earth required to make them bombproof; another objection to the triangular magazine is the indifferent stowage which it affords in proportion to the space taken up, and the heavy guns now used for siege purposes consuming a much greater bulk of powder than was formerly required, the question of stowage is increased in importance.

Rectangular powder magazines were universally adopted and approved of, as shown in Plate 3.

When the preparations for the expedition were going on at Varna, the frames, splinter proofs, and sheeting for magazines complete, of the dimensions and scantling laid down by General Pasley, were made and embarked; when however the rectangular ones arrived at the Royal Engineer park before Sebastopol, it was, after due consideration, determined to alter the mode of fixing the frames, placing them so as to suit the stowage of the ammunition boxes lately introduced into the service.

The supply of magazine timbers made of materials brought from Varna was necessarily very limited and soon exhausted, the greatest part were constructed from the wood obtained on the spot, by cutting down trees and dismantling houses.

The frames were in some cases placed at the sides (as in Pasley's pattern), but frequently as gallery frames (see Figs. 4 and 5, Plate 3).

As in a great many instances the excavation for the body of the magazine was made in rock, the height of the frames was not more than would allow two boxes to stand one above the other: when the soil was good the height was from 4′ 2″ to 5 feet interior dimensions, and the breadth was the same; when practicable the floor of the magazine was sunk 10 feet below the ground, in all instances a roof of splinter proof timbers of the largest available dimensions, about 9″ × 6″, but ranging from 5″ × 4″ to 13″ square, was laid over the frames; these were covered with a course of fascines or sand bags, and then again with such an amount of earth as to obtain a total thickness of not less than 9 feet.

Advantage was taken, in some batteries, of the geological formation of the soil: where the upper stratum was of rock about 5 feet thick, overlying a stratum of clay about 6 feet thick, a gallery was driven into the clay, the rock forming a natural roof, and the floor consisting of a stratum of shells, underlying the clay: props were placed in such magazines, near the mortar batteries, as a precaution against the concussion of heavy mortars; natural caves in the oolitic limestone rock were converted into magazines by building up the entrances with walls of sandbags and dry stone; the depôt magazines were in all instances formed in these caves, in the sides of the ravines leading to the trenches.

The length and direction of the passages of magazines depended a good deal on the form of the ground; the length of passage shewn in Fig. 5 is unnecessarily great for ordinary purposes: the general principle followed was that the mouth of the passage should be turned away from the enemy's fire, and that there should be two returns in it, so that a shell exploding at the mouth of the passage should not penetrate into the body of the magazine.

LOOPHOLES.

Loopholes were made in the advanced trenches, for the sharpshooters, of sandbags and sometimes of stone, the narrowest part being inside; their construction and dimensions depended on local circumstances. They were generally arranged or altered by the sharpshooters to suit their own convenience.

Some wooden trough loop holes having been found in abandoned Russian works, similar ones were made and tried, but were universally condemned by the sharpshooters, as the smoke hung in them so much that they could not see the result of their shot without putting their heads above the parapet.

In cases where a wooden loophole was near a sandbag or stone one, they invariably used the latter in preference to the former.

The object intended to be obtained by the use of the wooden trough loophole was to give more cover over a man's head, the loop hole being so long that it could be placed low down in the parapet.

Some loop holes were constructed by placing casks side by side, so that they joined at the bung diameters, above which a loop hole was formed by crowning the tops of the casks with rows of sandbags, to cover the heads of the sharpshooters: others were made by placing powder barrels on end at short intervals apart, the tops of which were level with the interior crest of the parapet; these were crowned with sandbags and were found to answer well.

The small sandbags were found to be so easily penetrated by the Minié rifle balls that the larger bags were preferred for loop holes in the advance.

MEDICAL OFFICERS' HUTS.

In consequence of the distance of the advanced trenches from the camp, it was considered necessary towards the latter part of the siege to establish bomb proof cover for the medical officers, in order that they might be able properly to dress the wounds in a temporary manner, and sufficiently to enable the men to be carried up to the camp.

These bomb-proof huts were made of the same materials and strength as the magazines, but were not sunk so deeply, and were so arranged as to admit the light better.

They varied in dimensions from 6′ × 6′ (interior dimensions) to 6′ × 15′, the height in the clear being 6′ 6″.

SUPERINTENDENCE AND LABOUR.

The construction of the trenches and batteries of such great extent entailed a demand for working parties which at various periods of the siege it was very difficult, and often impossible, to obtain, in consequence, in the first instance, of the limited number of troops available to guard the position and protect the trenches, and subsequently in consequence of the reduced state of the Army caused by sickness.

The working parties were obtained entirely upon requisitions on the Adjutant General; but, with a view to lessen the demand, a regiment of Turks was obtained from the Contingent attached to the British troops, and quartered at Balaklava; this regiment was encamped on ground near the Royal Engineer Right Attack Park, and was, in point of employment, entirely at the disposal of Captain (now Colonel) Gordon, R.E., but owing to the Turks' habits the overslaughs were enormous, and not more than from 400 to 500 men were available for work.

The night work and winter weather, combined with other causes, led to awful diminution of the numbers of these Turks, by death or by disease, and in January the daily number available seldom exceeded 200, who used to be employed, in consequence of the scarcity of transport, in conveying stores and materials to the batteries, or in bringing them from the half way depôt at the Col de Balaklava. In order to give the Turks a stimulus to work, soon after the commencement arrangements were made to pay them daily at the close of the work; each sapper superintendent was furnished with a certain number of tin tickets, and he gave one to each man who had performed a fair day's work; if a man had worked particularly well, he gave him two, and from the idle these tickets were withheld. A sergeant of sappers, on the arrival of the parties in camp, gave a day's pay for each ticket.

This system was found to answer well, and to induce the Turks to earn their pay.

During the winter the demands for working parties were sent in daily by the Commanding Royal Engineer, but were frequently much reduced, and not complied with; it was found impossible to do more than keep up the works already constructed, and clear the trenches of snow, advance was out of the question.

Early in the spring the contemplated French occupation of the Mamelon, as an emplacement for a battery against the Malakhoff, led to the construction of No. 9 Battery in the Right Attack; but as the British army could not furnish the necessary working parties, the French undertook to do so, and thus the parapet was thrown up under the superintendence of our Engineers with a party of French, who were found to be very diligent workmen. The Sappers' work of the battery was performed by the British.

When operations were actually resumed in the spring, working parties of the Line were again furnished, and continued to be so till the close of the siege; but some circumstances connected with these parties appear to be deserving of record.

When a party was made up by detachments from different Regiments, collected probably under an officer who of course could not know his non-commissioned officers or men, the difficulties of the Engineers in keeping them at work were great, and the confusion in case of night alarms was generally fatal to a proper resumption of the work. Experience is strongly in favour of working parties being taken regimentally, and not by detachments.

It is to be observed that there was rarely a sufficient number of Engineer officers for duty in the trenches, the work they had to superintend being scattered over nearly nine miles of trenches and batteries, mounting about 200 guns and mortars.

They could therefore devote but little time to each of the several works in progress, and the efficiency of the working parties depended much on the zealous co-operation of the regimental officers.

Each working party had one or more Sappers attached, and when they were experienced and well trained they were of the greatest possible assistance, and performed their duties in a most creditable manner.

However, from the hasty way in which it had been found necessary to increase the corps of Sappers and Miners, to meet the pressing demand of the war, many of the younger Sappers were sent out insufficiently instructed in their duties, which they had to learn during the operations of the siege, and therefore did not render that assistance which is expected from members of the Corps. This explanation appears called for, as it has been remarked by persons unacquainted with the facts that some of the Sappers did not come up to their preconceived opinion of them.

In the latter part of the siege, in consequence of the rocky nature of the soil in which works had to be carried on, and the scarcity of men of the Royal Sappers and Miners, 100 men were sent from different Regiments of the Line, and were attached to the Royal Engineer camp, these men, most of them practised quarrymen, were of great assistance, and worked very well under the superintendence of some corporals of the Royal Sappers and Miners, specially selected for the purpose.

The officers of Engineers were empowered to demand a proportion from the night guard of the trenches to be employed in the works, providing that they could be so employed without risking the safety of the trenches.

In the last few weeks of the siege, the practice of demanding the night working parties from the guards of the trenches was discontinued, and a special working party of 600 men was sent down for the purpose, who were completely under the control of the Engineer officers until the end of the night's work, when, unless the General of the Trenches considered their presence necessary to strengthen the guards of the trenches, they were sent home. This was found a very superior arrangement to the other.

Tools.

The tools which have been in use throughout the siege have proved of good quality and lasted well, considering the great wear and tear caused by working in such rocky ground, added to the fact of their being so constantly put into the hands of men not accustomed to their use.

The wheelbarrows were too weak for the nature of the service, and in repairing them the sides were strengthened with hoop-iron bands. The cast-iron wheels are very much to be condemned for their brittleness. Wooden ones were latterly made to replace them.

GEORGE BENT,
Major, R.E.

A. COOKE,
Captain R.E.

C. B. EWART, R.E.,
Major of Brigade.

Camp, Left Attack,
20th July, 1855.

DESCRIPTION OF THE VARIOUS KINDS OF MATERIALS USED IN THE CONSTRUCTION OF FIELD WORKS.

Siege of Sebastopol, 1854 *and* 1855.

NAMES.	Length.	No. of Pickets.	Diameter.	Height of webbing	Length of Pickets
	ft. in.		ft. in.	ft. in.	ft. in.
Wooden gabions (common)	..	12	2 0	2 9	3 6
Ditto (large)	..	10	2 6	3 9	4 6
Iron gabions	..	9	1 10	3 3	4 6
Fascines, 5 iron hoops to each	..	..	0 9	..	..
Iron hurdles	9 0	14	..	3 3	4 6
Wooden ditto	7 0	11	..	3 0	4 6
Ammunition barrels	1 9	..	1 6	..	..
Powder boxes	1 9	..	1 5	..	..
Sandbags	2′8″×1′2″	..	..	..	..
Barrels, supplied by the Commissariat, various sizes					
Bread bags from Commissariat	3 0	..	..	..	..
Ditto least size	2 4	..	..	..	..

RETURN OF PLATFORMS TAKEN UP IN THE BATTERIES OF THE FIRST PARALLEL, SHEWING THE QUANTITY UNSERVICEABLE.

	Serviceable.	Unserviceable.	Total.
No. 2 Battery, 5 platforms of 49 pieces each	209	36	245
„ 3 „ 3 „ „	127	20	147
„ 4 „ 4 „ „	166	30	196
Alderson's siege platforms. The loss of the materials was mainly attributed to the absence of the rear trucks of the gun carriages.			
	502	86	588

Return shewing the number of Gabions, Fascines, Sandbags, and Breadbags, expended on the Right Attack during the Siege before Sebastopol, from 18th October, 1854, to the 8th September, 1855 :—

Common Gabions	13,052
Iron ditto	1,437
Fascines	1,876
Sandbags	159,853
Bread bags	3,413

Expended on the Left Attack from 18th October, 1854, to the 8th September, 1855 :—

Common Gabions	3,963
Iron ditto	870
Fascines	904
Sandbags	176,492
Bread bags	4,000
Hide bags	40

OBSERVATIONS ON THE CONSTRUCTION OF THE SIEGE WORKS THROWN UP BEFORE SEBASTOPOL;

BY LIEUT.-GENERAL SIR HARRY JONES, K.C.B., COMMANDING THE ROYAL ENGINEERS AT THE SIEGE.

The Report of the Committee which I directed to assemble for the purpose of placing on record the details of the execution of the siege works thrown up before Sebastopol, although very clear and satisfactory as far as the works to which it refers are concerned, is not sufficiently comprehensive so as to give a full and correct knowledge of all the various operations performed principally by the Royal Engineers and Royal Sappers and Miners. The object of the present Paper is to notice those works which have not been referred to by the Committee, and observations are made relative to many subjects connected with the siege upon which they were not required to report.

DIFFICULTIES IN OBTAINING MATERIALS

One of the greatest difficulties which the Engineers had to contend against was the entire absence of every resource in the way of materials ; the few houses existing when the army arrived before Sebastopol were soon pulled down, the timber was carried away for fuel for the troops, and nothing remained but a few stones : there were no inhabitants, except in the small town of Balaclava ; the ground occupied by the French and English armies was a barren waste, wild and uncultivated. The heights of

Inkermann were covered with brushwood (young oaks principally) but these soon disappeared, being cut down and the roots grubbed up for fuel, of which there was a great scarcity throughout the winter of 1854-5; unfortunately the Engineers were soon deprived of this resource and were unable to procure more than a small number of oak saplings for gabions: these made very good gabions, strong and durable, but rather heavier than the ordinary gabion.

The heights above the village of Karani also afforded some brushwood, but at some miles' distance from the Engineer parks. Balaclava did not possess resources of any kind; in fact the position of the army resembled a barren island more than any portion of *terra firma*, every thing required had to be procured at Constantinople or along the shores of the Black Sea; and for the principal articles, such as tools, platforms, iron, sandbags, &c., recourse was had to the Arsenal at Malta or England. Under such circumstances, the Engineers had great difficulties to overcome from the deficiency of every thing they required to carry on an attack against works of such an extent as the fortifications of Sebastopol.

GABIONS.

From what has been stated above it is evident that from the difficulty of procuring brushwood there was always a great deficiency of gabions, and at one period of the siege it became necessary to send for the materials to Sinope. The French had to send to Constantinople and Varna, and paid a large price for them: those from Constantinople were made of the same description of wood as the bread baskets used in that city; they appeared to be tolerably strong, were approved by the French, and made close work.

A new description of gabion was made with the iron bands which came out on the trusses of hay, and hoops from the Commissariat stores; it must be borne in mind that such resources will seldom be found with an army in the field, and therefore must not be calculated upon at any siege inland.

The great concussion of the heavy guns and the lightness of the soil of the parapets soon made the wooden gabions lose a great portion of the material with which they had been filled. Whenever the iron bands can be procured in any quantity it will be desirable to work them up into gabions.

It is very much to be regretted that the metal gabions proposed by Capt. Tyler, R.E., and of which a large number had been forwarded from England, did not arrive until two days after the fall of the place. No opinion therefore can be offered as to their merits or demerits. *

TIMBER.

Timber was extremely difficult to procure: the scantlings were very small (4″ × 4″) yet of these many gun platforms were necessarily made, which, when spiked down to the sleepers, answered very well.

No pieces of timber could be procured long enough to make "lean-to" splinter proof cover in the batteries, which was very much required; many lives would have been saved had there been any, and they would have afforded cover from the heat in summer. They are, at all times, most desirable in batteries and in situations exposed to a fire of shells.

TRANSPORT.

The Engineers experienced very much the want of a Field Equipment properly horsed, similar to Batteries of Artillery; had such an establishment been formed, many of the difficulties experienced in getting materials from Balaclava to the parks would not have been occasioned, as the horses of the Brigades could then have been most usefully employed in bringing forward the gabions and platforms which were left at the railway station to be conveyed to the front whenever an opportunity presented itself, preference being given to other articles which, in the eyes of the authorities, appeared more important.

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* See Paper on Iron Gabions; by Capt. Tyler, R.E., in Vol. V of this Series.—ED,

Sand Bags.

The consumption of sand bags at the siege was enormous, arising in a great measure from the want of other materials suitable to the purposes for which they were used, and from the officers of Engineers not considering the difficulty of procuring them, and permitting a very lavish expenditure of them, by allowing them to be used in almost every case possible. There were also a great many issued to the Artillery for the purpose of carrying shot and shells to the batteries: these were all lost to the Engineers, as none ever came back, and thousands were to be seen lying about the trenches. It would be very desirable that some contrivance should be made for the conveyance of shot and shells, and whatever may be approved of should be sent out with the Battering Train, and form a part of its equipment; thus the Artillery would always have at hand the means of readily moving their shot, &c.

The Russians used sand bags of various sizes, much larger than those used in the British service, to be employed according to the situations for which they were intended, and when no heavy fire was bearing upon the work at the time the men were placing them; under such circumstances the weight, when filled, was of little consequence in regard to the number of men required to lift one.

They were very usefully and successfully placed on the parapets of the advanced rifle-pits, and upon the parapets of the main inclosure round the town. The larger description of sand bag might be used with advantage for the revetments of embrasures and for covering the roofs of rectangular magazines, &c.

Tools.

Tools were generally good, the complaints made occasionally of the badness of the cutting tools could, in almost every case, be traced to the ignorance of the men, their not knowing how to use them properly, and to the tools not having been sent out in the proper state for use, that is, ground or set, and, in many cases, from being used improperly. On one occasion a party of men were seen picking up stones near their camp with their bill-hooks!!

It would seem desirable that some long-handled shovels should be sent out with every Engineer Siege Equipment, and the Sappers practiced in the use of them.

Mantlets.

Mantlets should in every operation be prepared for the embrasures of all batteries, the range of the Minié rifle being so great that the most distant batteries will hardly ever be safe without them. Those used at the siege of Sebastopol were made on board the fleet, they were sufficiently large to cover the entire opening of the embrasures, and were made with a slit at the lower end to permit of the gun being run out and leave a small opening for the Artilleryman to point his gun. These mantlets were made of one layer of tarred rope, and were suspended by ropes from a beam resting upon two adjacent merlons; these, if well made, would appear to answer well.

The Russian mantlets were composed of three layers of tarred rope secured by two pieces of the same at the side of the mantlet. In some of their batteries a piece of the same material was fixed upon the gun in front of the trunnions, with a slit in it, to facilitate the pointing of the gun.

LOOPHOLES.

The Committee do not appear to have considered this subject sufficiently when making their remarks upon the Russian wooden troughs or tubes: these were found generally in the parapets of their rifle-pits, built in when the parapet was formed; in many situations they are excellent, as they present a very small object to fire at, viz. merely the opening of the tube. The great objection against them is that the use of them is restricted to one object, as there cannot be any deviation in the direction of the fire nor in elevation or depression. They were usually placed at such a height from the sole of the trench or pit that the men using them were never exposed, as is the case with sand bags forming loopholes on the top of the parapet. As to the smoke hanging in them, this only occurred when the atmosphere was very dense, from rain or fog.

It is very desirable, where practicable, to use a much larger sized sand bag than the bushel, for forming loopholes.

BATTERIES.

Where heavy guns are to be employed the parapets should be made much thicker than at present; if in a light soil, from 25 to 30 feet will not be found too much, as from the concussion of the guns and the effect of the enemy's shells and shot, the parapet soon loses its solidity and form. The embrasures must be made at least of the size stated in the Report, two guns should occupy the space where three have usually been placed, and the traverses between them should be made much higher than the ordinary splinter proof traverse. For batteries where shell guns are used, a *shell room* should if possible be constructed. The distinguishing number given to each battery should be painted upon a board in large characters, and put up in the battery in some conspicuous part of it; and officers in their reports should be required to give the number of the battery, and not refer to the battery by the number of guns placed in it. This is usually done by the Artillery, and leads to much confusion, and often to very serious mistakes.

The plan adopted at Bomarsund, of making a battery entirely of sand bags, was on one or two occasions followed with great success; for a battery of six or eight guns, with traverses, the number of sand bags required will be very considerable, and not always to be procured. This mode of forming a battery will, in many exposed situations, be found comparatively safe and expeditious.

PARALLELS AND APPROACHES.

These were generally well laid out and executed, with the exception of drainage, which, not having been attended to in the first instance, caused much trouble subsequently, and many casualties occurred in consequence, by the men preferring to run the gauntlet along the rear of the trenches, in preference to wading through them half-leg deep in water. In the parallels and advanced trenches the parapets were much injured by the guards not keeping them in proper order, and by the young soldiers preferring to fire over the sand bags forming the loopholes. The names of the different parts of the attack should be painted on boards and placed in some conspicuous position, and finger posts pointing to the adjacent works should be erected; attention to this will prevent much confusion, and time will be saved in the arrival of parties at the works for which they have been told off; on several occasions the parties mistook the road, and half-a-night's work was thereby lost.

DRAINAGE.

What has been said above will apply with equal force to batteries; many of the batteries first erected could frequently not be worked, from the great body of water standing in them, and several magazines were near being flooded.

OBSERVATORIES.

This is the name given by the French to the places constructed to enable the officers of Artillery to observe in comparative safety the effect of their fire, or for the Engineers to reconnoitre the enemy's works. The absence of such accommodation in the earlier part of the siege caused the parapets to be seriously injured by the destruction of the revetments. Orders were given near the end of the siege that in every battery to be constructed an observatory should be made, and in the old batteries also where practicable.

CHEVAUX DE FRISE.

The iron *chevaux de frise*, the spears of which are packed in the barrel, appear to have answered very well, and withstood a fire of grape better than the wooden ones. These, as well as the abatis, should, if possible, be covered from the fire of Artillery. The *chevaux de frise* across the Woronzoff Road suffered from the effect of it. In this case cover could not be made on account of the Russian advanced picquets being so close to them. From want of cover the Russian abatis in front of the Redan and Malakoff were nearly destroyed, more especially the latter.

AWNINGS FOR THE TRENCHES.

When the great heat of summer arrived it was found very desirable to provide cover for the guards of the trenches; this was done by means of pieces of canvass, from 40 to 50 feet in length and 10 to 12 feet in breadth, which were stretched along the parallel. In a siege of long duration it would be advisable to provide such cover in the trenches, both for summer and for winter; the Engineers would, of course, point out the parts of the trenches where they could be fixed without exposure to the enemy's fire or impeding the communications.

WATER.

A good supply of water is always required in batteries and trenches, and arrangements should be made accordingly. At Sebastopol the metal powder-cases made excellent cisterns when buried in the ground and placed at convenient distances along the parallels: they were filled daily.

BATTERING TRAIN.

In forming a siege train in future, a large supply of 8-inch mortars, and Coehorns, with pierriers, should be added, as they are easily moved, and require much less powder and labour in carrying up the shells to the advanced batteries than those of larger calibre. Rockets will be found very useful in many situations where it might be difficult to bring up Artillery: an *emplacement* for half-a-dozen rocket stands is rapidly made in any part of the trenches where it is advisable to use them. Wall pieces will be found extremely useful, as well as a large proportion o hand-grenades: although the enemy's works may not be near enough to throw them by hand, they would prove very annoying to an enemy when thrown from 8 or 10 inch mortars at a high elevation. Both the French and English suffered very much from this description of fire during the close attack.

Sapping.

No observations can be offered respecting the sap, as the kneeling sap was *not* attempted at any period of the siege either by the English or French, except by the latter only during the last few days of the siege, after the enemy's fire of artillery was completely subdued. The standing sap should be practised by the Sappers when under instruction, as there are many situations where it can be carried on when the ordinary, or kneeling, sap could not be executed without great loss.

Reliefs.

The reduced state of the army in point of numbers, and the great extent of the trenches, caused the reliefs to take place according to circumstances, and not at the hours usually observed at sieges, which it is so desirable to adopt. During the greater part of the siege the working parties were furnished from the guard of the trenches, according to the will of the officer commanding, so that the Engineers never knew exactly the number of men that would be told off for the working party. A diminution of 100 to 200 men in the number demanded, and ordered by the Adjutant General, frequently occurred. The reliefs of the Sappers and Engineer officers were necessarily regulated by those of the troops. This is mentioned in order that the practice at the siege of Sebastopol may not in future be acted upon or given as a precedent to be observed.

Scaling Ladders.

The 12 feet joint scaling ladders appear to be the most useful on all occasions; when used, a number of 6 feet joints should be added, according to the number of ladders, to be used in the event of a certain number of 12 feet lengths not being found sufficiently long for the purpose for which they are required. This plan was attended with advantage in the last attack upon the Redan.

HARRY D. JONES, Lieut. General.

To the Inspector General of Fortifications.

March 6th, 1856.

PL. 1.

FIG. 1.

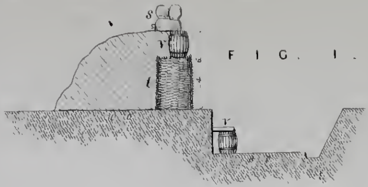


FIG. 2.

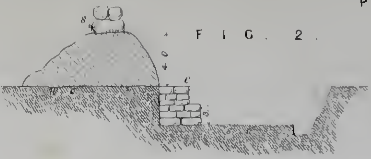


FIG. 3.

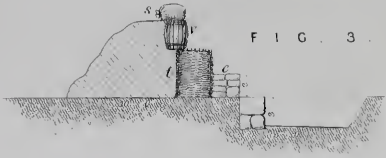


FIG. 4.

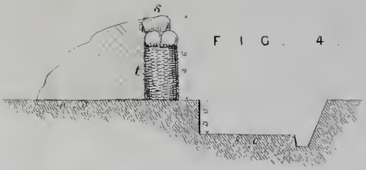


FIG. 5.

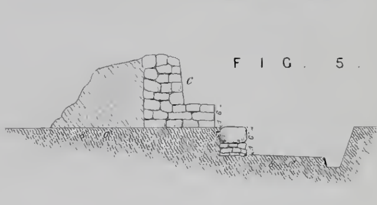


FIG. 6.

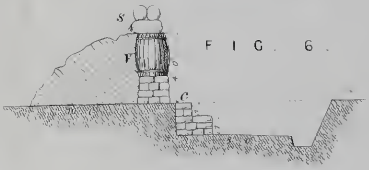


FIG. 7.

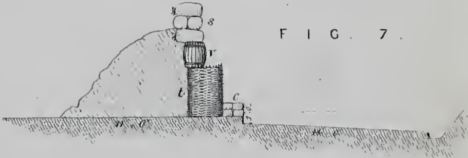


FIG 8.

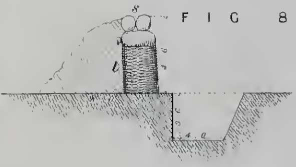
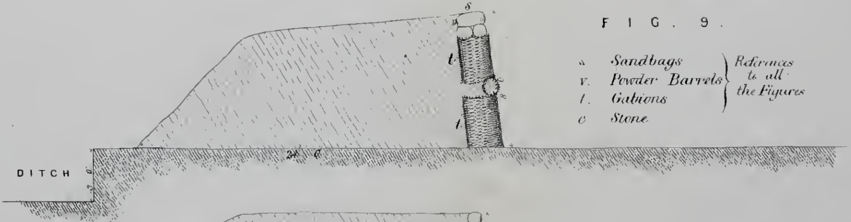
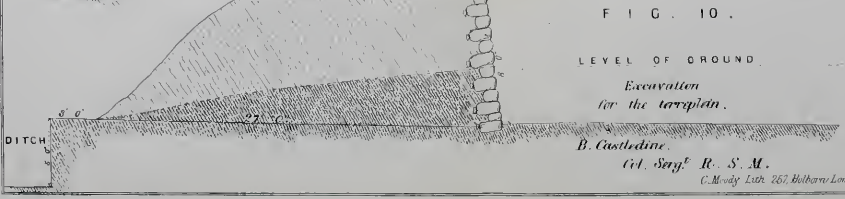


FIG. 9.



s	Sandbags	References to all the Figures
v.	Powder Barrels	
t.	Gabions	
c	Stone	

FIG. 10.



B. Castledine.
Col. Serg.t R. S. M.

C. Moody Lith. 257, Holborn London.

GUN PLATFORMS.

FIG 1

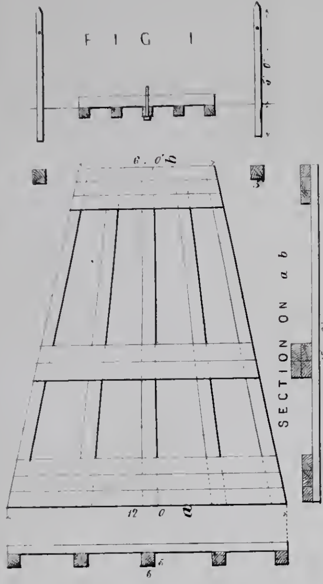


FIG 2.

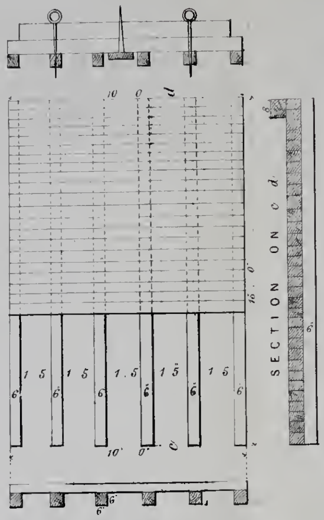
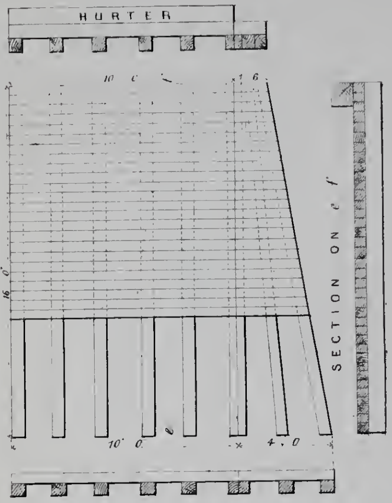
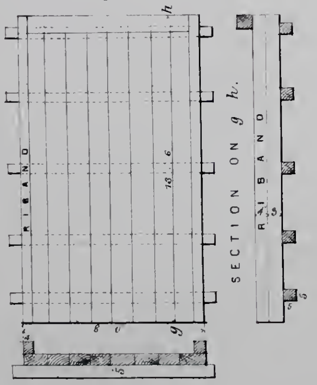


FIG. 3.



GUN PLATFORM.

FIG. 4.



MORTAR PLATFORMS.

FIG. 5.

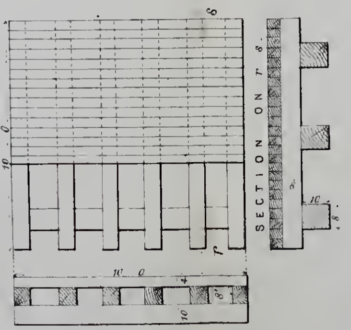
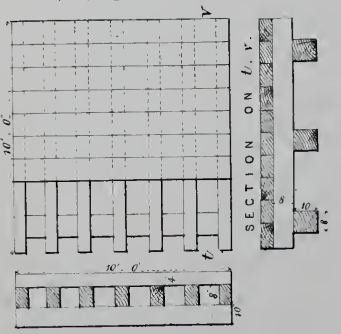


FIG. 6.



B Castledine
Col^r Serg^t. R. S. M.

C Moody, Lith, 257, Holborn, London

POWDER MAGAZINES.

FIG. 1.

SECTION ON *c. d.*

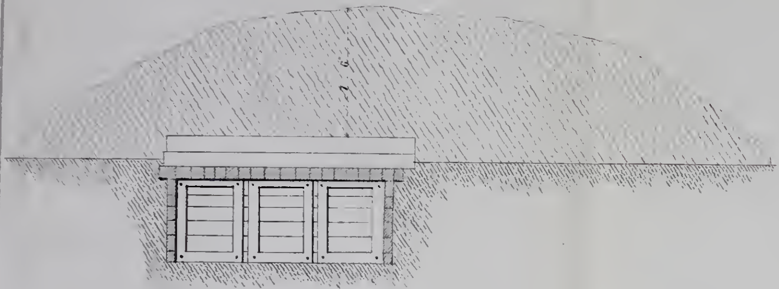


FIG. 4.

SECTION ON *a b e*

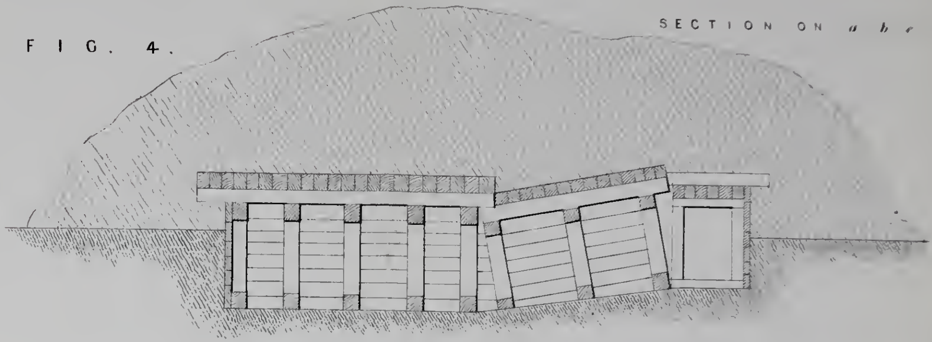


FIG. 2.

SECTION ON *a. b.*

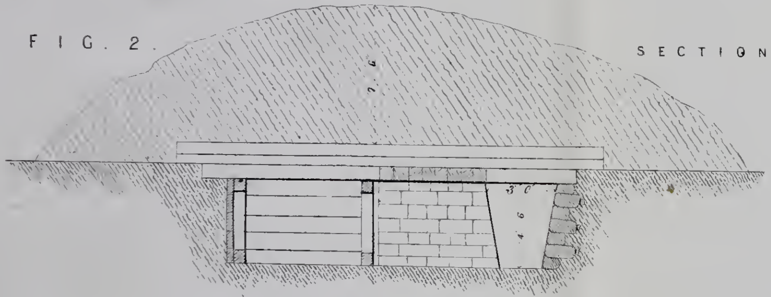


FIG. 5.

SECTION ON *g h. r f.*

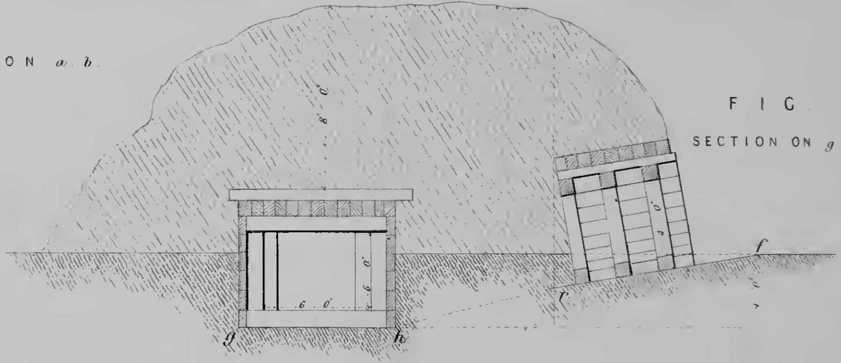


FIG. 3.

PLAN

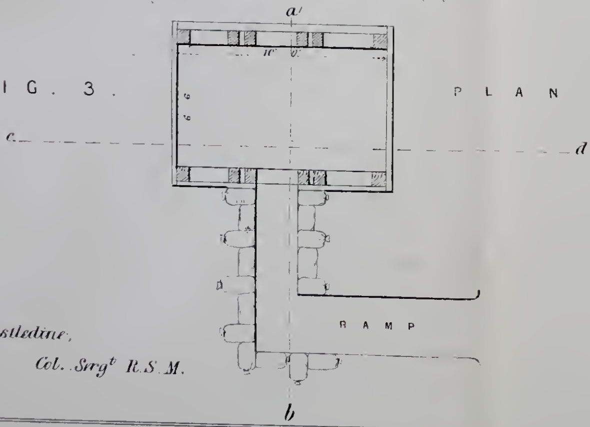
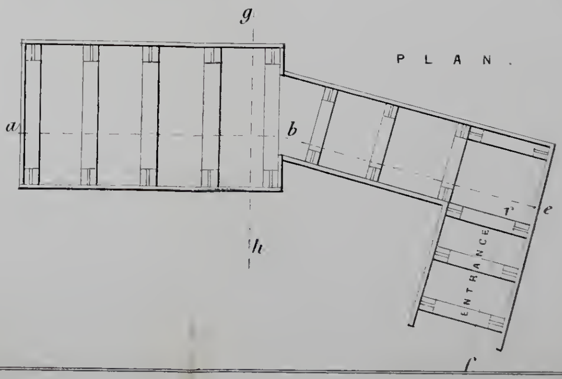


FIG. 6.

PLAN.



B. Castledine,
Col. Srgt. R.S.M.

[illegible]

PAPER II.

REPORT ON THE DEMOLITION OF THE DOCKS AT SEBASTOPOL.

BY MAJOR L. NICHOLSON, R.E.

POSITION OF THE DOCKS.

The inner or dockyard harbour of Sebastopol, round which are placed the dockyard establishment, is on the south side of the Great Harbour, and it lies between the town of Sebastopol and the Karabelnaia suburb.

The inner harbour is formed by two creeks, which are the continuations of the ravines called the Woronzoff and the Karabelnaia: these creeks unite, and have but one entrance into the Great Harbour.

At the southern extremity of the Karabelnaia Creek are placed the dry docks, the demolition of which forms the subject of this Report.

GENERAL DESCRIPTION OF THE DOCKS.

To give place for the docks and the adjacent buildings (see plan No. 1) the rocky banks of the ravine have in places been excavated, and the earth from this excavation has been deposited in the ravine, forming an immense embankment across it, immediately to the southward of the docks.

The ravine is usually dry, but a large body of water flows down it after heavy rain; and the natural channel for the flow of this water having been blocked up, it was either intended to pass through a drain constructed for this purpose in the embankment, or allowed to percolate through the soil; no appearance of a drain is to be observed on the southern side of the embankment, but there was an iron grating in the main culvert which emptied the docks, leading one to suspect the presence of such a drain, and that it was obliterated either intentionally, or in the construction of works of defence across the ravine.

The hill in which the excavations for the docks have been made is composed of clay and strata of limestone, and the whole of the ground abounds in land-springs, the level of the water being at an average depth of 25 feet below the level of the coping.

The foundations of the east and centre docks were on the natural soil, and the revetments of the sides of these docks were not carried down with a perpendicular backing, but were stepped in the natural soil. (See sections.)

But the west dock, which appears to have been built in the old bed of the ravine, was constructed partly on piles; and its revetments, unlike those of the east and centre docks, were perpendicular at the back.

The docks were five in number and similar in form, though they varied in size; of the three which had their entrances into the basin on the south side, the east dock was 210 feet long, and 95 feet wide; the centre dock was 206 feet long, and 95 feet wide; and the west dock was 204 feet long, and 85 feet wide; and the two docks which lay to the north of the basin were each 188 feet long, and 92 feet wide. All were 29 feet deep.

Between the three docks to the south and the two docks to the north lay an extensive basin, of a nearly quadrangular form, surrounded by a revetment wall, with a sloping face 30 feet in height; and the communication between this basin and the sea was by means of three locks, the height of the bottom of the basin above the level of the sea being about 27 feet.

The docks were built above the sea level; the floors of the three southern ones being about 6 feet, and those of the two others about 10 feet above that level.

There not being any tide in the Black Sea to fill the docks, water for that purpose has been brought from the Tchernaya, which being conveyed by canals, tunnels, and aqueducts, emptied itself into the basin, from which, as a reservoir, the docks were filled by means of two culverts, leading through the revetment on either side of the entrance to each.

The three southern and the north-eastern docks were emptied by means of a culvert which ran along behind the ends of the docks, communicating with each in turn, and finally leading into the sea below the locks. This culvert or issue drain is shewn by dotted lines (Plate 2). The north-western dock communicates with the sea by means of a separate culvert.

In case of the waters of the Tchernaya failing through long drought, three large pumps, worked by a steam-engine, were added, which forced the water from the sea, at a point close to the locks, into the aqueduct, and thus into the basin. The position of the engine house is shewn on Plate 1.

The revetments of the docks are formed in three massive steps, with an average rise of 8′ 6″, and with a tread of equal dimensions, the back varying, as has been stated, according to the soil in which they were built, that is, they were perpendicular where formed in made or uncertain ground, but where the soil was rocky, or could be depended upon from other causes, the back, like the front, was formed in steps. (See Sections, Plate 4).

The revetments of the basin, of the entrances to the docks, of the sides, and of the ends of the docks, and also the floors of the docks, were built of limestone of two descriptions, one of a soft nature taken from the quarries at Inkermann, and which is easily dressed with a saw, the other of a harder nature, taken from the quarries between the camp of the Allies and the town, and which was dressed with mallet and chisel, and used in places where most exposed to wear and tear, and also in the backing.

The work is all ashlar, formed with large stones. The mortar used has certainly not been of a very binding nature, since there is scarcely an instance where two stones have remained joined together subsequent to the explosion, and though used to a copious extent in the backing, which is composed of very small stones, it has been very sparingly used in the ashlar work itself.

With respect to the bond, throughout the extent of the work there is no trace of any between the ashlar and the rubble backing.

All the copings of the docks and of the revetment of the basin are of granite of two or three sorts, one a most beautiful description of blue granite, a second scarcely inferior to it, of a red color, and very close in the grain, and a third which is far inferior to either of the others, being exceedingly coarse and brittle. The blue granite or syenite has been most used in the large keel blocks, placed along the bottoms of the docks, and in the stone quoins at each side of the entrances, whilst the two other descriptions appear to have been used indiscriminately in the coping, steps, &c.

The work on all the granite is good, and the stones cut to receive the heel posts of the gates are beautifully wrought.

Description of the different portions of the Docks.

The entrance to each dock was closed by means of a pair of curved iron gates, their convexity being towards the basin, to resist the pressure of the water.

These gates were of English manufacture ; the frame-work was of cast iron, and consisted of heel and toe posts with horizontal ribs ; these were bolted to each other, and the sheeting, which was made of wrought iron plates half an inch in thickness, united together, and similar to boiler plates, was bolted to the frame-work.

The heel posts were hollow, and rested on solid iron pintles, built into granite blocks below ; and to each half gate were attached two rollers, which ran on iron racers, when the gates were opened and shut, the opening and shutting being performed by manual labour applied to capstans.

The iron racers were fixed to the stone work of the sill, but when actually closed the gates rested on timbers of great strength, firmly fixed together, and they shut against a massive framework, raised about 9 inches above the sill, which, being in the form of a triangle, with its apex towards the basin, gave great additional strength to the lower part of the gate. The whole of this wooden superstructure was supported on other timbers of large dimensions, laid transversely, in the east and centre docks on the solid rock, and in the west dock on piles. In the course of the mining operations it was found that this superstructure supporting the weight of the gates offered more resistance than any other portion.

Counterforts.—To the revetments of the docks and their entrances there were no counterforts, but those of the basin were strengthened by large counterforts, placed at an average distance of 14 feet from centre to centre. A counterfort was also placed behind the walls of the pier-heads, between the docks. (See Plate 2.)

The front of the revetment wall of the basin was built with a batter, and the back was parallel to the front for about two-thirds of the way down, and perpendicular for the remainder of the height. (See Sections, Plate 4).

Extent of Demolition allotted to the English.

It was decided that the demolition of the docks should be executed by the French and English ; and the southern half of the basin and the three docks adjacent to it were allotted to the English.

First Grand Project of Demolition.

The original project for the demolition of these docks was drawn up in the first instance with a view to their most complete destruction.

Thus it was intended to place the charges quite under the foundations of the revetments of the sides of the docks, and at two lined intervals with two lined craters ; one large charge was to be in the centre of the curved end, and a smaller one at either side of it.

It was proposed to place five charges under the floors of the docks, at three lined intervals, and with three lined craters, and under the sill of the entrance one very large charge of 8,000 lbs., whilst another charge was to be placed in the centre of the block at the end of each of the piers between the docks. This project was however set aside, on account of the depth of the shafts, and the great quantity of powder that would have been required; and as it was considered unnecessary to make so complete a demolition, the charges were reduced and a new project was proposed.

Second Project of Demolition.

A total demolition having been relinquished, it was considered that the docks would be effectually destroyed by a line of charges under the centre of the floor of each dock, and a line of charges all round the sides, so placed as to blow out the two bottom steps.

With the assistance of some Russian plans and sections, it was laid down as shewn in Plate 2.

The charges were to be at two lined intervals, and were calculated to produce two lined craters. With this intention, the charges in the sides and circular ends were to be placed at a depth of 31 feet below the surface, and so that the curve described with the line of least resistance as a radius, and each charge as a centre, should pass through the re-entering angle formed by the second and third steps from the bottom; and being placed at two lined intervals, the sides and end of each dock required 23 mines, with lines of least resistance of 12′ 11″, 12′ 9″, and 12′ 6″ respectively, to demolish the whole extent of wall.

The floors of the docks, which were supposed to be more strongly built than they were in reality, were to be destroyed by 11 mines in the east and centre docks, and by 8 in the west dock; these also were to produce two lined craters, and to be placed at two lined intervals, the line of least resistance in the two former being 13 feet, whilst that in the latter was 13 feet 9 inches.

Two charges in the bottom of the entrance to each of the docks were to be so placed that one should destroy the masonry outside the wooden framework, whilst another, placed immediately below the framework itself, was intended to effect its destruction.

The line of least resistance of the mines in the entrances of the three docks would have been, in east dock and centre dock, 12′ 8″, and in west dock (the entrance to which was much smaller than either of the others) 10′ 10″.

The revetments of the sides of the entrances to the docks were 13 feet in thickness, and to destroy these it was deemed necessary to place three charges at the back of the wall, which were to produce two lined craters, and were situated at two lined intervals.

As has been before mentioned, a large counterfort was situated exactly behind the centre of the revetment of the pier at the entrance to the docks; to destroy this and the whole of the revetment at the same time, it was considered advisable to place the charge well back in the counterfort, and by thus lengthening the L.L.R., embrace the whole extent of the wall; the line of least resistance of this charge was thus 17 feet.

In the basin wall the counterforts were supposed to be placed 40 feet apart; and to destroy it charges were to be placed in the centre of each counterfort, and smaller charges were to be situated in the intermediate spaces.

Calculation of Charges.

In calculating the charges for the mines above described, the rules resulting from the experiments made by Sir Charles Pasley, Sir Harry Jones, and others, were taken as a guide, though from local causes it was considered advisable to make some alterations in the charges thus obtained.

Throughout the whole extent of demolition, charges producing two lined craters, and at two lined intervals, were to be used, therefore the mode of arriving at the correct charge for revetments without counterforts was by taking $\frac{3}{20}$ of the L.L.R. of each variety of mine; but where counterforts existed the charge was estimated at $\frac{1}{5}$ L.L.R.^{3}

With this view all the charges in the revetment walls of the docks, and in the spaces between the counterforts of the basin walls, were originally calculated at $\frac{3}{20}$ L.L.R.^{3}, whilst $\frac{1}{5}$ L L.R.^{3} of the mines in the counterforts of the basin wall, and also of the mines placed in each of the counterforts situated behind the wall at the end of each pier between the docks, gave the charges for those mines.

It was at first supposed that all the revetments of the docks were perpendicular at the back, and the charges, calculated at $\frac{3}{20}$ L.L.R ^{3}, would then have been placed in the revetment itself; but it appeared, from the excavations in the east dock, that this was erroneous, and that they were stepped in rear as well as in front, that is, that the ground itself was stepped to receive the masonry, therefore it followed that the charges, instead of being placed in the masonry, would in reality be situated in the earth or rock behind it; so it was feared that, as the mere facing of stone would not offer so much resistance as a solid revetment, the craters from this cause would not meet, and hence it was considered advisable to increase all the charges placed behind the revetments of the docks from $\frac{3}{20}$ to $\frac{7}{40}$ L.L.R.^{3}

Description of the Demolition as actually Executed, shewing all the Alterations in Shafts, Galleries, and Charges, with Reasons for making them, also the Difficulties, and how surmounted.

As has been before stated, the original plan for carrying out the project for the demolition of the docks was to place the charges in the several positions allotted to them by sinking shafts through the ground behind the revetments, as it was supposed that the difference of time between working in the earth behind, and through the masonry steps, would be very much in favour of the former; but as the works progressed, it became evident that the soil at the back of the revetments of the east dock, and of the east revetment of the centre dock, was as difficult to work as the masonry of the revetment itself, therefore all the shafts behind these walls were at once relinquished, and the following shafts were sunk in the steps, viz., Nos. 20, 19, 18, 17, 13, 14, 15 and 16, in the east dock, and Nos 1, 2, 3, 4, on the east side of the centre dock, (see Plan 2); and No. 32 was sunk in the landing at the head of the centre dock; but Nos. 7, 5, 8 and 31, in the west side of that dock, and Nos. 12, 11, 10, 30, 28, 21, 22 and 23 had progressed too far to render it worth while to change the plan of operations; Nos. 29 and 35, also, at the ends of the other docks, had been sunk to a considerable depth; these shafts were therefore made use of for the charges to be placed under the steps.

A culvert for the purpose of emptying the docks led through the revetment at the circular end of each, from thence under the second step in the east side of the east dock, and from this point, taking a direction behind the revetment of the basin, it emptied itself into the sea, below the locks.

This culvert was connected with the three docks by smaller feeders (see Plan 1) and as it was ascertained that it was nearly on the proposed level of the charges, it was made use of as a main gallery for those in its vicinity, and in some instances the chambers were made in the culvert itself; Nos. 67, *a* and *b*; No. 64, *a* and *b*; No. 61, *a* and *b*, and the ten mines communicated with by shafts Nos 17, 18, 19 and 20, in the east revetment of the east dock, were all situated in it, or in short galleries branching from it.

Culverts for the purpose of filling the various docks were constructed in the revetments on either side of the entrances, and as these were situated at the bottom of the revetment, short galleries were driven from them, at the ends of which the charges destined for its destruction were placed; all the charges numbered on the Plan, Nos. 62 *a*, *b* and *c*; 63 *a*, *b* and *c*; 65 *a*, *b* and *c*; 66 *a*, *b* and *c*; 68 *a*, *b* and *c*; and 69 *a*, *b* and c were accordingly so placed.

A shaft No. 70, had been sunk at an early stage of the operations to a considerable depth, close to the large counterfort at the end of the pier between the centre and west docks, for the purpose of ascertaining the form of the revetment, and it was therefore sunk to the whole depth of the revetment; and a short gallery from its bottom communicated with the charge placed at the back of the counterfort; but as no corresponding shaft had been sunk in the end of the pier between the centre and east docks, it was considered that to drive a gallery branching from the culvert 63 would be an easier method of reaching the proper position of the charge, and this was accordingly done.

A similar method of placing the charge marked 69 *a′*, in the counterfort of the south-west angle of the basin wall, was also adopted.

All the charges at the back of the west revetment wall of the basin were to have been placed by means of shafts sunk behind that revetment, and the shafts marked 25, 26 and 27, were actually sunk for this purpose, 27 communicating with three, 26 with four, and 25 with three charges; but these shafts were so much damaged by a heavy fall of rain, which completely saturated the ground, (Dec. 15th) that Nos. 26 and 27 were relinquished, and four galleries were driven from the face of the wall at its bottom, each gallery communicating with two charges, No. 25 being repaired and communicating with one charge placed to the north of it.

The culvert running along the back of the east revetment wall of the basin was made use of for lodging the charges, in the same way as the same culvert running behind the east wall of the east dock, and on the supposition that the counterforts were placed 40 feet apart, a similar arrangement of charges was proposed as that for the west wall; namely, charges in each counterfort, and smaller ones to fill in the intermediate spaces; but on destroying the west wall, which was executed at an earlier period than any other part of the demolition, it was found that a mistake had occurred with respect to the distance between the counterforts, which was less than was expected, and that, instead of being 40 feet apart, they were only 12 feet in some places, and 20 feet in others; charges were therefore placed in each counterfort, and the adjacent craters meeting, no charges in the intermediate spaces were required; being placed in the culvert, it was not considered necessary to sink so many shafts as would have been required had galleries been driven, therefore a circular man-hole which communicated with the culvert was used as one shaft, and another, No. 38, was sunk at the angle of the wall.

To lodge the charges placed beneath the floors of the docks, one shaft of the proper depth was sunk for each pair of charges, and galleries communicating with them were driven north and south, the chambers being excavated on one side at their extremities.

A similar method was adopted also with respect to the pairs of charges placed in the sills of the entrances. (See Plan 2, for all the positions of the charges.)

The method above described, of placing the different charges, was that eventually carried out in the greater part of the demolitions, but as in some instances this method was found impracticable, alterations in the depths of the shafts, and also in their arrangement, were found to be absolutely necessary, and these alterations I shall now proceed to describe.

The west dock having been constructed in a soil where water was more abundant than in any other part, it was with great difficulty, and at the cost of great labour, that the shafts behind the revetments could be sunk to a greater depth than 26 feet, (the apparent level of the water); added to this, a heavy fall of rain, which descended on the 15th of December, 1855, filled a great number of them, and rose to a height of 2 feet in the bottoms of the docks themselves.

Previous to this date, pumps had been procured to reduce as much as possible the water already in the shafts, but it was soon found that no amount of pumping would clear the works of the body of water that was now present in them; therefore, it became advisable (owing to the very limited supply of pumps) to relinquish for a time the worst shafts, until a portion of the docks had been destroyed, and a greater amount of labour could then be expended on the worst portion; thus time also was allowed for the partial subsidence of the storm water: when this occurred, however, it was found utterly impracticable to sink all the shafts of the west dock to the proper depth, therefore it was determined to place some of the charges in its revetments, and in a horizontal plane 6 feet above the original level.

The shafts thus altered are numbered 24, 23, 9, 10, 11, 12, and when this alteration was made Nos. 24 and 9 were found to be so completely destroyed by the water, that instead of them, shafts were sunk in the second step, (see Plan 2.)

The shafts in the bottom of the west dock, to attain the object originally intended, namely, the demolition of the centre line, should have been sunk to a depth of 13′ 9″, but this also was found to be absolutely impracticable, owing to the vast quantity of land springs that existed; the galleries were in consequence commenced at a depth of 7′ 6″ (see Sections, Plates 3 & 4), and it was hoped that by surcharging these mines, the craters would be so extended as to cause them to unite.

In the bottom of each of the three entrances, one shaft was to be sunk to communicate with the two charges to be placed in each, but this arrangement was also subsequently altered.

When the two charges placed in strict accordance with the 2nd project, in the entrance to the centre dock, were exploded, it was found that the resistance offered by the frame-work supporting the gates was so much more than that offered in a horizontal direction by the masonry to the north of this frame-work, that both the charges blew out in the direction of the L.L.R. of the most northerly one, (see dotted line, Plan 2, shewing the crater thus formed); it therefore became evident that not only was a great increase in the charge necessary, but also a different arrangement; with this view, two branch galleries were driven from the end of the south gallery of No. 45, (see Plan 2), and charges were placed at their extremities calculated for a L.L.R. of 11′ 6″—thus, 700lbs. in two charges, instead of 300lbs. in one, were used, and a much longer line of tamping was obtained.

In No. 46, by the explosion above alluded to a perpendicular face was exposed to view, shewing that no damage whatever had been done to that portion of the masonry which carried the wooden frame-work.

A gallery was therefore driven into this, in the centre of the entrance, and when it had attained a length of 19 feet branch galleries were driven to the right and left 9 feet in length, and two charges, of 200 lbs. each, were placed at their extremities.

In No. 47, a shaft had been sunk with the intention of lodging the two charges at a depth of 10 feet 10 inches below the surface, but the water was so great an impediment that, though two pumps were kept constantly at work, it was found totally impossible to drive the gallery under the wooden frame to a greater length than seven feet, and all hopes of driving the north gallery were entirely given up; therefore at this point the work was stopped, and a large charge of 500 lbs. was lodged, instead of the two proposed to be placed in a similar manner to those in No. 45.

Preparing the Charges.

The larger proportion of charges were placed either absolutely in water, or in very damp earth; and when water made its appearance in great quantities it became evident that boxes constructed in the ordinary manner would not answer.

Barrels of various sizes, 36 gallons, 10 gallons, 26 gallons, one or two of larger dimensions, and breakers, were with this view procured from the Fleet and the Commissariat; besides these, many old Russian powder boxes were re-soldered and repaired, and a small quantity of English powder boxes were also made use of; with this variety of boxes and casks the charges were sometimes composed of three or four boxes or barrels stowed away in the chambers in the most compact form, and to make up for loss of power sustained by its not being placed in one case, an addition in proportion to the number of boxes, &c., was always made to the charge.

A casemate (see plan No. 1) existed in the neighbourhood of the docks, and this was turned to the purpose of a magazine, earth being thrown on the top of it to make it bomb-proof, and a traverse, composed of ships' tanks filled with earth, was constructed to shelter the doors from shells or splinters.

The casemate was about 40 feet by 20 feet, and a wall being built across it, the powder was stowed away in the inner half, the outside half being used as a filling room.

As great care was requisite to insure all the casks being perfectly water-tight, they were, with the exception of the English powder cases, submitted to the proof of an air-pump, and re-coopered or re-soldered, according to the repair they required; the barrels or cases were then taken to the magazine, and filled by Artillerymen appointed for that purpose, the primers fixed, the loading holes plugged, and both pitched before leaving the filling room.

Loading.

When filled at the magazine, all the barrels and cases were properly slung with ropes, ready for at once lowering into the shafts and galleries; thus prepared they were carried, by means of poles on mens' shoulders, to the head of the shafts for which they were intended, then lowered into them, and slid on skidding into their proper positions; but many of the shafts were so full of mud and water, that in executing this service the men employed were sometimes above their waists in it, and great difficulty was experienced in moving the larger casks, weighing in some instances 320 lbs., along galleries presenting so many obstacles; under these circumstances of course it was impossible to place the cases empty and then fill them, whilst to ensure safety to the charge, and rapidity in placing it, it was found that no case containing more than 100 lbs. could be conveniently handled; however it was impossible to obtain a greater number of the smaller kegs, so the use of the larger casks was imperative.

Tamping.

This, as a general rule, was performed by packing the galleries with sand bags, and filling the shafts with earth and clay firmly rammed; but in many instances it was considered advisable to strengthen the tamping by means of timber, either let into a chase at the mouth of the gallery, or placed diagonally across the gallery close to the chamber.

The issue drain, described above as leading behind the revetment of the East Dock, was tamped with sandbags, between the pairs of charges placed in it, and it was intended to tamp the whole when the charges were laid, but time would not admit of this, and a different plan was adopted, which will afterwards be described.

FIRING.

Owing to the dampness of the shafts and galleries, it was deemed inexpedient to use powder hose for firing the charges, as so much difficulty existed in making the hose and troughs perfectly watertight.

It was contemplated to fire the mines by Bickford's fuze, but this was considered so uncertain in its rate of burning, and altogether so doubtful an agent, that this idea also was relinquished; however it will appear that in the actual progress of demolition both were used to some extent.

Having given up all intention of firing either by powder hose or Bickford's fuze, permission was requested from Vice-Admiral Sir Edmund Lyons to use the Voltaic batteries, sent out by the Admiralty for the purpose of destroying sunken vessels; Mr. Deane, in charge of the apparatus, was ordered to place himself in communication with the Commanding Royal Engineer, and it was then arranged that a bomb-proof hut should be constructed for him in rear of the Dockyard wall, and in line with the Centre Dock; in this the batteries were placed. (See plan No. 1.)

The batteries were ten in number, with ten cells in each, and the connection between the batteries and the foci of the wires leading to the sets of charges was by means of insulated copper wires, covered with galvanized iron wire; thus the copper communicated with one pole of the battery, whilst the galvanized iron communicated with the other.

From the focus of any set of charges two wires led to each; to ensure safety from damp these were passed through a plug about 6″ in length, and tapering from 2″ to 1½″ in diameter; and their points were connected by platinum wire, which being made red hot by the Voltaic current, ignited the charge.

The plug was driven firmly into the head of each cask through a hole drilled for that purpose, and a copper nozzle was soldered to the top of the metal-lined cases, into which the plug was inserted in a similar way; when the plug was thus driven, a mixture of pitch, bee's-wax, and tallow was laid all over that part of it which projected above the cask or case.

The wires leading from each charge were brought to the top of the shaft, and from thence to the end of the galvanized iron wire, which was in general led to a spot on the coping equidistant from the two outside charges of any set that was to be exploded; one wire from each charge was then connected with the insulated copper wire leading from the batteries, whilst the other was connected with the galvanized iron; thus the current from the batteries was distributed amongst all the wires leading from the focus to the charges, producing, when no failure from imperfect connection, damp, or other cause occurred, a simultaneous discharge of that set of mines.

Sets of charges varying from three to eight were fired in this way, but it was not supposed that the batteries were strong enough to discharge more than that number.

Another mode of firing the charges was by passing the current through a number consecutively, *i.e.*, in each set, one wire of one outside charge was connected with the galvanized iron wire, and one from the other outside charge was connected with the insulated copper wire, inside the galvanized iron wire, and the intermediate charges were all connected by the wires leading from them; thus, instead of the circuit being divided at the end of the galvanized iron wire into a number of smaller circuits, as in the former plan, the main circuit was complete through the charges themselves; by this method a large quantity of wire was saved, and also time in making the great number of connections, incidental to the first method.

The objection to this latter method was that an accident occuring to the platinum wire in *any* charge caused a failure of the whole set, which was not the case in the former; though the risk of a bad connection amongst the number that had to be made, when that plan was used, nearly counter-balanced this disadvantage.

Description of the Effects Produced by each Explosion, and of the Mode of Firing Adopted for each.

It was at first intended to fire several charges at once, but owing to the great quantity of water that constantly poured into the shafts and galleries, and the necessity for concentrating the labour as much as possible, it was decided to blow up different portions of the docks as they could be prepared.

The general mode pursued, preparatory to the discharge of any set of mines, was to clear them of water as much as possible during the night, to load as early in the morning as possible, and to complete the tamping by the following morning.

The first set of mines that were prepared, namely No. 42, two mines; 50, two mines; 49, two mines; 48, two mines; 59, two mines, in the bottom of the East Dock; and also those in the West Basin wall, viz. 27*a*, 2 mines; 27, 2 mines; 26, 2 mines; 25, 1 mine; and 25*a*, 2 mines, were loaded during the night, having been cleared of water during the day; but owing to the great difficulty that occurred in getting the charges to the shafts, and the inconvenience always experienced in carrying on operations of any nicety at night, the loading was afterwards always carried on during the day, the tamping being done at night.

The charges in the bottom of the east dock were fired by the voltaic batteries, the two wires from each charge being connected with the main wire, which arrangement will be always termed " crow's feet," from the form assumed by the bent pieces of wire that were attached to the galvanized iron wire, and also to the end of the insulated copper wire inside it, to the branches of which the different wires from the several charges were connected.

The charges, ten in number, were connected, in two sets of five each, with two main wires; and the explosions of the sets, though simultaneous in themselves, followed each other with a perceptible interval of a few seconds.

Of the ten charges, three missed (both the charges in No. 59, and one charge in No. 48,) the explosion of the remainder produced large well formed craters, tangential to each other, of an average depth of 4′ or 5′ below the original floor, and extending within 2′ of the steps on either side of the dock; the stone-work was completely disintegrated, and the massive granite blocks on which the keels of the vessels were to rest, and which weighed more than two tons each, were all displaced. No. 60 was not exploded with this set, as the gates were at the time being removed from the entrance of the east dock, and it was thought that the debris thrown from that mine would interfere with this operation. Therefore the two charges in No. 59 were untamped, and on removal were found to have failed from damp; they were then again loaded and tamped, and the gates being by this time removed, No. 60 was also loaded and tamped, and the three charges fired simultaneously, the voltaic circuit in this case being completed through the charges themselves.

The craters caused by these charges were similar to the last described, only a small portion of stone-work remaining intact between the circumference of the crater of No. 60 and the stone-work of the sill.

On the same day that the charges in Nos. 42, 50, 49, 48, and 59 were exploded, the ten charges in the west basin wall were also fired.

It was rendered absolutely necessary to discharge these mines on that day, as the French had determined to fire the mines in their portion of the wall contiguous to it, and it was expected that the shock would disarrange the galleries and shafts in that portion allotted to the English. The primers (as the wooden plugs through which the wires were passed into the cases were termed) were not ready for the ten charges to be placed in this wall, recourse was therefore had to Bickford's fuze, as a matter of necessity; and to insure the explosion of each charge, and also to make it as simultaneous as possible, three lengths of it were introduced into each barrel; the barrels being first placed, holes were bored in them with a gimlet, and the Bickford's fuze thrust in as far as possible; the joint was then covered with a mixture of pitch, bee's-wax, and tallow; the Bickford's fuze was laid in the angle of the gallery to the opening, all the lengths being cut alike; the galleries were then tamped, and at the time appointed (simultaneously with the French) the Bickford's fuze was fired.

The demolition caused by this set of charges was not as satisfactory as was expected; in the first place, a greater number of counterforts existed than were calculated upon; and in the second, one charge missed altogether, and a third blew out the tamping, destroying at the same time a portion of the face of the wall, close to the entrance of the gallery; still that portion which did fall, about two-thirds of the whole extent, remained at an angle of 45°, and but very few stones were thrown to any distance.

Two charges were subsequently placed in the counterforts of that portion of the wall that remained standing, the effect of which was its total destruction.

From this it appeared that the charges, calculated at $\frac{3}{20}$ L.L.R.^{3} for the mines between the counterforts, and $\frac{1}{5}$ L. L. R.^{3} for those in the counterforts themselves, were but just sufficient for the purpose, and that instead of placing those in the counterforts in their centres, and in a line with the back of the wall, had they been placed further back in the counterforts a more complete demolition would have been the consequence.

January 2nd.—Thirteen charges, communicated with by shafts Nos. 43, 54, 55, 56, 57, 58 and 46, in the bottom of the centre dock, were fired by means of the voltaic batteries.

These charges were connected by "crow's-feet," in two sets of six and seven, with the main wires, and exploded simultaneously, only a few seconds elapsing between the two distinct discharges.

In loading these mines greater care was taken in the preparation of the charges, commencing loading at daybreak in the morning; the mines were all tamped by half-past four o'clock in the afternoon, though, owing to the time occupied in making so many connections, the explosion did not place till dusk.

Only one mine missed fire, and as that was in the centre of the dock, it was not untamped.

The destruction of the bottom of the dock was most complete, giving sufficient proof that the amount of powder calculated at $\frac{3}{20}$ L.L.R.^{3} was ample, and yet not enough to project any large stones beyond the limits of the dock; but with respect to the two charges placed under the wooden frame-work and masonry of the entrance, from the effect produced, there could be no doubt that, from the immense resistance presented by the massive beams, the line of least resistance lay through the tamping, and not in a direction perpendicular to the charge, for both blew out in the direction of the north charge, destroying the masonry entirely, but leaving the frame-work untouched, the crater assuming the form shewn in Plan 2, with a perpendicular face on its south side covered with diagonal ploughed and tongued sheeting, about 4″ in thickness, which was added evidently to give greater resistance to the horizontal thrust occasioned by the gates working on the frame-work.

A fresh gallery was therefore driven through this face, 8′ from the surface of the framework or superstructure, and 12 feet in length, and branches were formed 10 feet long to the right and left of it. (See Plan, No. 2).

The next discharge of mines was to have taken place on January 8th, and 25 mines were prepared to be fired by the voltaic battery.

The shafts communicating with these charges (see Plan No. 2) were numbered 61*a*, 61*b*, placed east and west of the issue drain, leading from the head of the east dock; No. 13, 3 charges; No. 14, 2 charges; No. 15, 2 charges; No. 16, 2 charges, on the west side of east dock; No. 4, 2 charges; No 3, 2 charges; No. 2, 2 charges; No. 1, 3 charges, 64 *a* and *b*, east and west of the issue drain leading from the entre dock; 32, 2 charges; and 31, 1 charge, at the east side and head of the centre dock.

The 25 charges were all placed in their positions by the close of the evening of January 7th, and the tamping was completed by the morning of the 8th.

The method of passing the current through the charges was adopted on this occasion; and they were accordingly divided into two sets of 12 and 13; thus the charge in the north branch of No. 1 was attached to the galvanized iron wire, the charge in the south branch of No. 14 was attached to the insulated copper wire inside of it, and the intermediate charges in Nos. 2, 3, 4, 16 and 15 being all connected together, the circuit through 12 charges was rendered complete; in like manner the remaining 13 charges were connected with another main wire, 61*b* in the east dock, and the east charge in No. 32, central dock, being the outside charges. Great, however, was the disappointment when, on attaching the poles of the batteries to the main wires, it was ascertained that not one charge would explode.

On the following day the galvanometer was brought to bear on the wires leading from the different charges; any break which has occurred in the connection is at once detected by the needle remaining motionless, and by this instrument it became evident that some accident had occurred to the greater portion of the charges, and that the connection was perfect only in both charges in No. 4, No. 3, No. 2, and two in No. 1, the remaining charge in that shaft being doubtful; one charge in shaft No. 15, and two in the south branch of No. 13 were all right; this being the case, it was determined to connect the wires of the eight safe charges, and of the doubtful one in the central dock, by " crow's feet," with one main wire, and fire them at once, which was accordingly done on the following day, and the eight charges exploded simultaneously, leaving the ninth unexploded.

By the explosion of these eight charges, of 370 lbs. each, the two lower steps were completely destroyed, but the corner nearest the entrance and a part of the upper step still remained standing, though considerably shaken; only a small portion also of the wall above the upper step was completely carried away, though the remaining part was useless for any practical purpose; (the corner and the small portions of the upper step and wall were afterwards destroyed by small charges); the effect produced by these charges was a sufficient proof of the correctness of the calculation, as the lower step was completely torn up; though it was evident that, owing to the rocky nature of the soil against which the revetment was built, to produce a slope of 45° it would be necessary to place the charges much further back, and therefore greatly increase them.

The charges, the connection with which had, by the galvanometer, been proved to be broken, were now untamped and laid bare, and those in the east dock being ready first (that is to say, before Nos. 32, 64 *a* and *b*, and 31), two lengths of Bickford's fuze were inserted into each of the eight, and a fresh bag of powder of 60 lbs. weight added, in case any of the powder should have got damp. Bickford's fuze was used instead of the wires, as the primers were not ready, and a necessity for urging on the work with all despatch existed.

The Bickford's fuze in this instance was led to the summit of the shaft through hose casing, the better to insure its burning throughout. Three charges still remained to be fired by the wires (namely, that in the north branch of No. 15, and two in the south branch of No. 13;) these were accordingly connected with the battery, the circuit passing through the charges; these three charges still contained 390 lbs., not having been uncovered, whilst the charges in the south branch of No. 15, 2 in 16, 2 in 14, 1 in 13, and 61 *a* and *b*, were increased to 450 lbs. for the reasons above stated.

The three charges fired by the batteries were first exploded, and those fired by Bickford's fuze followed at regular intervals.

By the simultaneous explosion of the three charges fired by the batteries, the two lower steps were completely destroyed without projecting any stone beyond the opposite revetment; but by the various discharges of the mines of 450 lbs. each, the stones were thrown to great distances, and not a vestige of the steps remained, the craters being well defined, and of great depth, shewing that the wall had been torn from its very foundation; still great portions of the wall above the upper step remained adhering to the solid rock behind, though in some places undermined by the force of the explosion. These portions of the wall were afterwards brought down by a succession of smaller charges lodged behind it.

On the 15th January, the charges in No 64 *a* and *b*, and the two charges in No. 32, being uncovered, Bickford's fuze was also fixed into them, and they were fired in the afternoon of the same day. A complete destruction of the steps at the head of the centre dock was the consequence of this explosion, and not a single stone was thrown beyond the crater, though the work was completely torn asunder.

Owing to the failure described in the effect of those charges placed in the sill of the entrance of the centre dock, an alteration was made in the arrangement of those in the entrance to the east dock. (See Plan No. 2).

The north branch of No. 45 in that entrance remained the same, but from the end of the gallery driven on the south side of the shaft two branches were driven at right angles to it 12′ long, and at the extremities of these two charges of 400 lbs. were placed, with L.L.R. of 13′ 6″ to the surface of the wooden frame work.

The proper charge for this mine, calculating it at $\frac{3}{20}$ L.L.R^3, would have been 367lbs. but owing to the enormous resistance offered in the entrance of the east dock, it was considered advisable to make these two charges up to 400 lbs. each; these charges were fired by the batteries, the current passing through the charges consecutively. The effect was the complete destruction of the masonry outside the frame-work, and also of the frame-work itself, enormous masses of timber being lifted on to the top of the piers on either side of the entrance, and some smaller pieces being thrown to a distance of several hundred feet.

On the following day 2 charges of 200 lbs. each were placed in the galleries driven below the frame-work of the centre dock, where a previous explosion had failed; in this case the L.L.R. was 8′ 6″ to the surface of the wood-work, and the proper charges would have been 90 lbs.: but these were increased to 200 lbs. each, on account of the great resistance of the timber that remained above, unmoved by the former explosion, and of the mass of masonry that had been blown from the north side of the sill.

These charges were fired in a similar way to those in the entrance to the east dock, and though the effect of the discharge was not to project the beams of wood to so great a distance, the frame-work was completely uprooted, not a vestige remaining in its original position; the crater in this instance was deep, and extended nearly the entire width of the entrance.

The destruction of the floor of the west dock followed next in order.

On the 18th January, all the galleries having been with great difficulty and exertion driven to their proper extent or nearly so, and pumped by relays of men clear of water during the night, loading commenced at daybreak, but the mud and water in the shafts Nos. 44, 51, 52 and 53 remained to such a depth that more trouble was experienced in getting these charges placed than in any other throughout the work, and it was only by dint of keeping constantly pumping throughout the operation that the men were enabled to work at all.

The charges in this instance were not placed at two lined intervals, for the reasons already assigned, but as they were not deep enough to ensure the craters intersecting, the charges were increased, so as to develope the craters as much as possible, thus the L.L.R. being 7′ 6″, the proper charge would have been only 63 lbs. to produce a two lined crater, calculating it at $\frac{3}{20}$ L.L.R^3; but the charges were laid amongst piles on which the floor of this dock was built. and the large beams laid across the tops of them were expected to offer great resistance to the explosion, therefore they were all increased to 150 lbs.

The effect produced was not so violent as was expected from mines so surcharged, but the craters extended considerably beyond the radii of the **L.L.R.** though they did not quite meet, still only one or two of the red granite blocks remained in their original position, and but a small portion of the masonry of the floor of the dock at the foot of the lower step was unmoved by the explosion.

On the 19th January, the mines placed in the feeder drains on the east and west sides of the block between the entrances to the east and centre docks, namely, No. 63 *a′*, *b* and *c*, and 65 *a*, *b* and *c*, and also the charge placed at the back of the counterfort at the end of the pier, marked 63*a* on the plan, were to have been fired simultaneously by the batteries.

The charge 63*a* amounted to 820 lbs.; those in the culvert 63 were 340 lbs each, whilst those in the corresponding culvert on the other side were 400 lbs. each, the gates having been removed on the east side, whilst a large portion of that on the west side remained standing, and was expected to offer great resistance.

These culverts were tamped almost entirely with sand bags, but in addition to this, timber was placed diagonally across them, so as greatly to increase the resistance, the line of tamping being considered too short from the outside mine to the entrance of each culvert.

The current in this instance was to pass through the whole set of charges, seven in number, but owing to a break in the connection, or perhaps to the irregularity of distance between the different charges, only one charge (63*c*) exploded, completely destroying that portion of the wall assigned to it.

The three charges in the culvert 65 were then connected afresh with the main wire, and by this means they were simultaneously exploded, completely demolishing the revetment, though from the rocky nature of the soil the ground behind it did not fall.

The mines 63 *b* and *c* were then untamped, and the wires proved which connected 63*a* with 63*a′* and 63*a′* with 63*b*; they were then cut, and on applying the galvanometer to the two wires from each charge they were all found to be correct, therefore it was proved that the previous failure was most likely owing to some earth connection between the charges. The culvert was then tamped, and the wires connected with a main wire on the top of the revetment.

On Tuesday, January 22nd, the charges 62 *a*, *b*, and *c*, in the culvert on the east side of the entrance to the east dock, and the ten charges placed in the culvert running behind the east basin wall were loaded; 62c was to be fired by hose, as it somewhat interfered with the arrangement of the wires, but the remaining 12 were divided into two sets of six each, and were connected together in the culvert, thus 62*a* was the outside charge of one set, one wire from this charge passing out at the north entrance to the culvert, whilst the other wire from this charge was connected with 62*b*, and so on to the charge on the south of shaft No. 38, up which one wire from that charge was led; in the same way the remaining six charges to the north of shaft No. 38 were connected, one wire being led up that shaft, while the connecting wire from the charge at the extreme end of the set was led up the shaft No. 39.

On the night of that day the charges in Nos. 35, 17, 18, 19 and 20, at the head and behind the revetment of the east dock were also placed.

No. 17 led to four charges placed in the culvert, whilst 18, 19, and 20 each communicated with two charges in the same culvert; as the arrangement of laying wires to four charges from one shaft was considered to be rather too complicated, it was thought to be better to connect the eight mines in 35, 18, 19, and 20 together by wires, and to fire those in 17 by means of Bickford's fuze; this was accordingly done, the west charge in No. 35, and the north charge in No. 20, being the outside ones of the set.

The charges in the feeder drain were 340 lbs. each, whilst those in the culvert of the basin wall, placed in the counterforts at irregular distances according to the project, differed in amount, varying from 112 lbs. to 200 lbs., and charges of 300 lbs. were to be placed in rear of the two re-entering angles of the wall.

The charges under the steps, at the head of the east dock, were each 390 lbs., and those in the culvert behind the revetment were to have been the same; but, owing to the necessity that existed to complete the demolition as soon as possible, it became evident that to tamp a culvert of such size would take some days to complete, therefore only portions of it were tamped where absolutely necessary, and the charges increased by 90 or 100 lbs. in proportion to their sizes; thus, the charges in 17 became 480 lbs. each, the shaft alone being tamped; those in 18, 19, and 20 were increased to 460 lbs. each, small portions of the culvert being tamped, and those in the culvert behind the basin wall were each increased by a bag containing 80 lbs.; those in the feeder drain were unaltered, as that drain was tamped nearly throughout its whole length; the tamping had also been completed between the charges in 17 and 18, between those in 18 and 19, between those in 19 and 20, and also partially between the north charge of 20 and 62*b*.

The two sets in the issue drain and in the basin wall were to be fired first, being in close proximity with the French mines, which were to be exploded on the same day (January 23rd), and at the moment when the Bickford's fuze ignited the different lengths of powder hose, the connection with these mines was to be completed, the wires from the battery passing as rapidly as possible from those of the first set to those of the second, but the instant of time, which of necessity elapsed between the two connections, was sufficient to enable the explosion of the first to destroy the wires of the second set before the current could be passed into them; thus it happened that only the set to the north of No. 38 shaft exploded, completely destroying the wall and counterforts, and leaving a perpendicular scarp of rock behind it; 62*c*, fired by hose, also exploded, destroying that portion of the revetment in its front.

Later in the morning the charges 63*a*′, 63*a*, and 63*b* were fired, producing most satisfactory results, not a stone being left unturned, and not a sign nor a vestige of the massive counterfort remaining.

The charges on the east side of the east dock were fired the same evening, but owing to some unexplained cause, only two in No. 35, out of the whole set of eight, exploded, producing the most entire demolition of the steps, and (as in 32, centre dock) not a stone was projected beyond the crater. Shortly after these two had gone off, those in 17, to which equal lengths of Bickford's fuze had been attached, exploded simultaneously, and as it is unlikely that such great lengths of this fuze should have burned in equal times, the probability is, that when one charge exploded, the absence of all tamping in the culvert, in which they were all placed, caused the others to ignite. The steps were by this explosion completely destroyed, the destructive effects extending as far as the south mine in No. 18, which was rendered ineffective by it.

On the following day the charges in 18, 19, and 20 were tested by the galvanometer, and the south mine in 18 alone being found to be unserviceable, the remaining five were fired by the batteries, the current passing through them consecutively. By this explosion all the steps were also destroyed, but portions of the revetment above the upper step still adhered to the solid rock behind it.

On the same day (Thursday, January 24th) the charges having been placed in the eight mines of shafts Nos. 8, 5, 6, and 7, and Bickford's fuze having been attached to them, these charges were also fired.

Originally the charges in these eight mines were each to have amounted to 363 lbs., but as the necessity for speed increased, and the galleries were not driven to their proper lengths, they were all more or less increased; thus in No. 7 there were two charges of 400 lbs. each; in No. 6 there was one charge of 400 lbs., and another of 416 lbs.; in No. 5 both charges were increased to 400 lbs., whilst in No. 8 the charge in the south branch was altered in position as well as size, for owing to the loosened state of the earth, it had been found impossible to place a charge in the north branch of 31, contiguous to it, therefore the south branch of No. 8 was driven a little further, and a short return made in it, so as to increase the L.L.R.; thus the charge in this branch was 464 lbs., and that in the north branch was 408 lbs.

Fired by Bickford's fuze, these eight charges exploded at different times, which would partly account for small portions of the wall remaining standing; but, on the whole, the destruction of the walls was exceedingly satisfactory, the difference of the effect on walls with earth backing being made evident in this case, as not only was the wall above the upper step displaced but large craters were formed in the ground itself.

Owing most probably to the north and south galleries of Nos. 6 and 7 not having been driven to their proper lengths, a portion of the wall remained between them, but in so tottering a condition that a small charge behind it displaced it without difficulty.

The mines in the culverts on both sides of the entrance to the west dock, and on the west side of the entrance to the centre dock, marked in the plan 69 *a*, *b*, and *c*; 68 *a*, *b*, and *c*; and 66 *a*, *b*, and *c*; also 69*a′* in the counterfort of the south west angle of basin, No. 47 in the sill of the entrance to the west dock, and No. 70 in the counterfort at the end of the pier between the west and centre docks, were next prepared. All the mines in the culverts were charged with 400 lbs.; 69*a′* contained 320 lbs.; No. 70, 800 lbs.; and No. 47, 500 lbs.; only three of these mines were connected with the batteries, the rest were to be fired by an arrangement of Bickford's fuze and powder hose; 69*a′* was connected with one main wire, whilst 47 and 70 were connected by "crows' feet" with another.

The tamping and loading of these mines were completed by the morning of the 26th January, the culverts being tamped in the usual way with sand bags, whilst the shafts were filled with well rammed clay and earth; but in No. 47, where the line of tamping was very short, and, the earth having fallen in, the chamber had become an immense cavern, it was necessary in the first place to fill it with sand bags, and to place sheeting firmly strutted against the mouth of the cavern; then, chases being cut in the shaft, other sheeting was let in, and the intermediate spaces filled in with closely packed sand bags; in the case of this mine not only was the resistance of the framework to be overcome, but one half of the gate, having become jammed when open, was placed exactly over the mine.

To fire the mines placed in the culverts, short lengths of Bickford's fuze were introduced into each charge, and powder hose was laid along the whole length of gallery, so that the Bickford's fuze, ignited by the hose, might simultaneously, or nearly so, ignite the charges ; this arrangement was also carried out in 69*a*′ in case of failure with the wires.

The three charges were first attempted to be fired by the wires, but only No. 70 exploded ; 69 *a*, *b*, and c, and 69*a*′ were successfully and simultaneously exploded by the hose and fuze, but in culvert No. 68, *a* and c only went off, and in 66, *b* and *c* both missed. It is most probable that these failures in the culverts were occasioned by the explosion of No. 70 disarranging the hose and Bickford's fuze.

After the explosions above mentioned, a fresh connection was made with the wires leading from 47, and the whole strength of the batteries was brought to bear upon this single charge ; at first it would not go off, but *after the current had continued to pass through the wires for about half-a-minute the charge exploded ;* and it is to be inferred from this that the priming of fine powder which was confined around the platinum wire in a small canvass tube was damp, and that the wire, remaining red hot, gradually dried the powder, and in process of time ignited it, thus firing the charge.

By these explosions the whole of the revetment west of the entrance to the west dock was completely destroyed, the made ground and masonry falling at an angle of 45 degrees.

Only a small portion on the east side remained standing, where 68*b* had not gone off, and this was shortly after destroyed by a small bag of powder placed in a short shaft behind; 66 *b* and c having missed, a large portion of the revetment still remained, but 70 and 66*a* completely destroyed the counterfort and the face of the revetment towards the basin. The effect of 47 was also extremely satisfactory, the framework being completely destroyed, and the gate thrown from its position, and a large chasm was left about 10 feet deep where the charge had been placed.

By this time the charges in the culvert behind the east basin wall, which missed on the 23rd, had been reached from a hole made in the debris thrown down by the discharge of the set to the north of 38, and it appearing that the wire was completely destroyed by that explosion, and some of the barrels smashed, fresh barrels were substituted, and powder hose was introduced into the whole of the six charges which missed on that occasion, namely, four in the culvert, and 62 *a* and *b* ; and on Monday, 28th January, these six charges were fired, their effect being completely to destroy the whole of the revetment, though a small portion of one counterfort remained standing.

Nothing now remained but the 23 charges in the revetments of the west dock, and that piece of the revetment which had been left by the failure of 66 *b* and c.

The opening of the culvert, marked 66 on the plan, was so choked up by the debris thrown down from the explosion of the north charge in shaft No. 7, and the wall itself appeared so unsafe, that another plan was resorted to for destroying that portion of the revetment wall ; nearly opposite the position of 66 c, and about half-way up the revetment, there was a hole in the wall through which the chain led, which by means of a capstan above, closed the opposite gate, this hole was about 10′ long, so it was made use of as a main gallery from which to drive another to lodge a charge which would blow down the whole mass; the gallery was driven in obliquely, so as to gain a point about half way between 66 *b* and c, and with a L.L.R. of 14′, a charge of 450 lbs. was lodged at the end.

On Tuesday, January 29th, the galleries in the revetments of the west dock, being driven to very near their proper extent, the loading was commenced, and the arrangements for firing were completed on Thursday, 31st, at an early hour.

The proper charge for these mines was 348 lbs., but owing to the galleries being shorter than their proper length, and also on account of the small amount of resistance which the made earth was found to offer when the charges on the west side of the centre dock were exploded, they were all altered according to the conditions under which they were placed; water was more abundant in these shafts than it had been in any of those behind the revetments of the other docks, and the charges were placed with extreme difficulty, but as it was intended to test the efficiency of the wires at this, the last explosion, the whole operation was performed with the greatest care, the galvanometer being always brought to bear on each charge before it was lowered, and before tamping commenced. One or two instances occurred where the connection was broken in the operation of getting the charge into its place, and a fresh charge and primer were substituted, and at length, when the 23 charges were tamped, in two only did the galvanometer indicate a bad connection or rupture. One length of Bickford's fuze was also fixed into all these charges except one or two, where the water was in such abundance that it was thought the risk of damping the charge by boring the hole for the fuze was too great.

The charges were to be united with the main wires by "crows' feet," three main wires being used, and the whole number of mines being divided into two sets of eight and one of seven, and the connection between the batteries and the main wires being made as rapidly in succession as possible, it was thought that the effect would be nearly simultaneous, but when the moment arrived for passing the current through the charges, not one would go off, and the cause of the failure admitted of no explanation, unless it was, that through carelessness in making the multitude of connections, some had become disunited, and the current returned to the batteries through the earth. Nothing therefore remained but to await the effects of the Bickford's fuze, which had already been lighted, and accordingly, one after another, 17 out of the 23 exploded, the remainder missing, most probably from the damp having penetrated the cases; those that failed were in the south branch of 24, in the south branch of 23, in the north branch of 22, 67 *a* and *b*, and the single charge in No. 30.

Many of these charges, it will be remembered, were placed at a higher level than that originally intended, and it was observed that these charges had not the effect of so thoroughly destroying the lower step as those placed at the bottom of the revetment; a difference was naturally to be expected, but not so great a one as was actually the case, and it is possible that the little resistance offered by the ground behind may have had an influence on the result; and in No. 28, as if to prove this, the ground being throughout very shaky, both charges blew up through the ground in rear of the revetment, leaving the wall itself only a little shaken.

As a remedy for the failures above detailed, it was at first proposed to untamp the shafts, drive galleries in from the second step, and place charges in the revetment, as well as make use of the old shafts; but after having untamped to a certain extent, it became evident that the ground was so shaken, and the framework of the shafts so unsafe, that the risk incurred would not be equivalent to the advantage; it was therefore decided to drive galleries from the first step from the bottom, 19 feet long from the face of the wall at a higher level than the known water line, and then branching to the right and left, place charges about 21 feet apart, the L.L.R. being about 12 feet, and the charges being slightly increased; thus (see Plan No. 2) four galleries were driven nearly opposite to the former positions of Nos. 24, 23, 28, and 30, only a short return being driven from the extremity of that opposite 24, and galleries to place the charges 21 feet apart, from those opposite the remaining Nos.

The charges were thus placed, one in No. 24 of 300 lbs, in 23 two of 500 lbs. each, in 28 one of 400 lbs. and one of 300 lbs., and the same in No. 30.

Powder hose was fixed to all these charges, and the work of driving the galleries being commenced on the 31st January, they were fired on the 6th February, the men having worked in reliefs, each relief having a task of 2 feet, and as soon as one set of men had finished their task another was ready to take their place. This plan was found to answer admirably when it was tried, but of course it could only be carried out when the amount of work to be done was limited in extent.

These seven mines exploded as nearly as possible together, and the effect produced by them was completely to destroy those portions of the wall left standing on the 31st January, and also the lower step. Now as these charges were all placed in the masonry itself, and not in the earth behind the masonry, it seems most probable that the slight resistance offered by the earth was the real cause of the lower step not being destroyed by the former discharge.

The charge placed in the chain hole, to destroy that portion of the revetment left standing by the failure of 66 *b* and *c*, was exploded on the 31st January, at the same time as those in the revetment of the west dock, and its effect was all that could be expected, namely, to remove the last vestige of the block at the end of the pier between the centre and west docks.

This brought the mining operations to a close, and as only here and there small portions of wall remained standing, the success, though not unmixed with many failures in the mines to be fired by wires, may be deemed a satisfactory proof of the truth of the calculations, and of what difficulties may be overcome by men working steadily in concert with officers who would spare no pains in the attainment of the desired object.

Time occupied in Demolishing the Docks.

The order for preparing a project for the demolition was issued immediately after the evacuation of Sebastopol, it having been agreed that the French should destroy one half of the docks and the English the other.

To obtain some verification of the Russian plans, which had been obtained when the Allies first occupied the Heights, some shafts were sunk in different places behind the revetments, and work was commenced with this object on the 13th September, the party consisting only of 1 sergeant, 9 sappers, and some miners from the Line, who marched down from the camp every day; but on the 19th one subaltern of Engineers and 42 men took up permanent quarters in the store-houses of the Dockyard, and the work was carried on in two reliefs until the 24th September, when orders were received to discontinue the work altogether.

On the 24th October, 60 more Sappers, with a captain and subaltern of Engineers, and a party of 50 men of the Line were added to the working party, making it in all 156 Sappers and 150 of the Line.

Up to this date there had been no work done beyond the regular hours, but water now began to throw great obstacles in the way of the speedy completion of the work, and to expedite it the 24 hours were divided into three reliefs, the whole or nearly all the shafts being worked during the first relief, as the day party still consisted of 150 men, and was of course only available for this relief, and in the second and third reliefs those shafts only were worked which were the most backward. To carry out this object more fully, viz., to work constantly at the backward shafts, 200 men were added to the permanent party, making it up to 350 men, but still retaining the daily party of 150 men.

The working party thus consisted of 156 Sappers and 350 Line, and with but slight alterations it continued so till within a fortnight of the completion of the work, when the daily party, which a short time before had been decreased to 50 men, was done away with altogether, and another detachment 150 strong marched to the Dockyard, 100 of those who had been on the works the whole time being relieved; thus the permanent party was increased to 400 men.

No great inconvenience from water in the shafts was experienced until the middle of November, when, the shafts attaining a depth of 26 feet below the coping, the quantity increased so rapidly that it became obvious that some other means than the bucket and pulley should if possible be resorted to, to clear them.

Eight force pumps were therefore procured from Balaklava; but these could only be applied to the shafts in the floors of the docks, as the depth of the other shafts was soon too great to admit of any pump raising the water to the summit.

The wet shafts were therefore worked day and night, for to allow a shaft to remain unworked for a few hours was to ensure its having some feet of water in it when work was recommenced. Some common lift pumps were made, and some old Russian pumps, found in the Dockyard, were also fitted up in the hopes that they might assist in getting the water out of the deep shafts, but they were found to be so awkward, and so constantly out of repair that the bucket was in the end found to be the best for the deep shafts.

Thus the work progressed with fortunately very fine weather, and it was thought that the shafts might soon be ready for the charges, but on the night of the 15th December, two or three days having been rainy, the docks were deluged by a tremendous storm of rain, and in the morning not only had the water risen in some of the shafts behind the revetments to within a few feet of the surface, but the floors of the three southern docks and of the basin were covered to a depth of two feet.

To pump out this body of water was of course out of the question, and it was at one time contemplated to put up one of the steam engines that the Russians had used in pumping out their coffer-dams, but this was given up, the labour being too great. The only alternative therefore appeared to be that the water in the shafts of the revetments should be permitted to subside, whilst, to work those in the floors of the docks, coffer dams were constructed to isolate them as much possible, and then to pump them out; but this not being found to answer, the French were requested to cut a drain through the sill of the gate leading into the locks, and as they kindly consented to this, the water was quickly reduced in the basin, as the cutting was below the level of the English docks; the feeders were made use of to empty them into drains cut through the bottom of the basin leading from each dock to the French locks. In this way the water was very speedily got rid of, but the work was very much thrown back by this great fall of rain, for many shafts and galleries, before almost completed, had now to be begun again.

On the 17th December the weather began to be exceedingly severe, and owing to the intense frost and the great risk run by men, who, working in wet shafts where the atmosphere was warmer than above, would, on returning to the surface, at times be frozen, the order was given to cease working at night, and the party was divided into reliefs, one half going on from 7 a.m. till 1 p.m. and the other from 1 p m. till 7 p.m., and this arrangement was adhered to until the work was completed, deviations from it being made when urgently required, such as preparing galleries, pumping shafts out preparatory to loading next day, or the like.

During the progress of the work the Russians at times fired a good deal in the direction of the docks, but their missiles fell short, and though the working parties had some extraordinary escapes, only one Sapper was wounded, and one private of the 18th Regiment lost his arm.

The barracks the Sappers were quartered in were large store-houses built on the wharf around the creek, and though large and well adapted for the purpose, they were very cold, and the men, returning night after night from the shafts wet through, suffered a great deal from cold and bronchial complaints; one or two shot fell in the barrack-rooms, but most providentially not one man was injured by them.

General Remarks on the Mining Operations in Sebastopol Dockyard.

Having now brought the details of the demolition to a close, some remarks upon the success of portions of the operations, and upon the failure in others, upon the different stages of the work, and upon the modes of firing which were used, may be added.

With respect to the mode pursued of lodging the charges, *i.e.*, the sinking of shafts and the driving of galleries, experience teaches that where shafts have to be sunk to so great a depth as 31 feet, a shorter line, though it be through a harder material, is decidedly preferable, owing to the great labour of raising the earth to the summit of such deep shafts, and, in the case of the docks, the material of which they were built was of so soft a nature that all the shafts ought to have been sunk in the second step, thus much trouble would have been saved in repairing those shafts destroyed by the storm water which fell in the middle of December, and there would have been no necessity for the enormous quantity of framing which was used in those shafts sunk in earth.

Sufficient care was not taken when laying out the shafts in the first instance, to place them exactly in the centre between each pair of charges; had this been done, much trouble would have been saved in the execution, and in taking the necessary measurements to ensure the charges being placed in their proper positions.

It will be observed, from the description of the operations and the actual demolition, that, as a general rule, where the charges exploded as intended, the effects were commensurate with the expectations; therefore we may conclude that the calculations founded on the rules laid down by Sir C. Pasley, Sir H. D. Jones, and others, are correct in every respect, except that, from the demolition of the east basin wall, it would appear, that instead of placing the charge in the centre of a counterfort, and in line with the back of the wall, it should have been placed nearer to the back of the counterfort; and judging from the portions of the steps and revetment which remained, it appears that in laying out a series of charges they should always be so arranged that the craters should intersect at least ¼ of the L.L.R., whereas in the project for the demolition the craters were arranged so as to be only tangential to each other.

Though the powder in almost all the mines was in barrels and cases of different shapes and sizes, placed in no particular order, the effect seemed to be the same as if the charges had been in one case, though only from 5 to 10 lbs. were added in consequence of the separation; but from the trouble we had in getting large casks, weighing in some instances 300 lbs., into the chambers, it would be as well never to attempt to lodge any cask or case already charged weighing over 100 lbs.

In fixing the positions of the shafts with respect to the positions of the charges, the proposed method to be adopted for firing should always be borne in mind, thus a great amount of extra trouble and time will always be saved.

In calculating and placing the charges in the revetments of the west dock, which were built in made earth, more attention should have been paid to the probable effect in the direction of the L.L.R., as from the effect produced I am of opinion that less charges in proportion (these were $\frac{7}{40}$ L.L.R.^{3}) placed in the masonry itself, and about two feet from the back, instead of in the back of the revetment itself, would have produced as much effect, and have thereby saved a considerable amount of powder; whereas in those of the other docks, which were merely a facing to the natural rock, though in every instance the lower steps were destroyed, yet a portion of the wall above the upper step almost always adhered to the rock, and it therefore seems that had the charges been increased in proportion to the L.L.R. and placed quite at the back, the whole revetment would have been blown down; but it is true, at the same time, that only the destruction of the lower step was at first intended.

The culverts, whenever they existed near any charge or sets of charges, were always used as main galleries, and as time would not allow of these being completely tamped, as has before been observed, one-third of the amount of each charge was added to make up for the deficiency; and in all cases of hasty demolition, it is worthy to note that if this addition be made, the necessity for tamping the shaft alone exists, which is of course an operation far easier to perform than tamping galleries.

As regards the four several modes of firing employed, viz., by the voltaic batteries, Bickford's fuze, a combination of Bickford's fuze and powder hose, and powder hose alone, I should, from experience of the former, express it as my opinion that where the person in charge of the batteries can be assisted by trained superintendents on whom he can completely depend, and when the time of completing any particular operation is not limited, nothing can be more perfect than the voltaic agency for firing charges placed in water; but as the chance of failure increases immensely in proportion to the number of connections to be made, and as every charge should therefore, to make the result perfectly sure, be connected by one unbroken wire, or rather by a wire not, as in the case of the dock demolitions, made up of many short lengths, it would be almost impossible to carry on operations on so large a scale as these unless the supply of wire was unlimited, and unless the person in charge of the apparatus was able himself to inspect all the minor operations connected with the wires.

It is obviously quite impossible to account for all the failures which occurred in those mines which were to be fired by the batteries, but the probability is that in many instances they were owing to earth connections, that is to say that, a break in the copper wire having taken place, the current immediately betook itself to the galvanized iron wire, and so back to the battery, without passing through the charges; in some cases also, the platinum wire was broken, but these failures might have been avoided had the galvanometer been used at an earlier period in the operations.

Two modes of firing by electricity were used, viz., by passing the current from the batteries through a set of mines consecutively, and by distributing the current from the end of the main wire amongst the charges, by means of two wires brought to a nucleus at its extremity from each of the charges in the set.

The advantage of the former is that the current passes through each charge with its entire intensity, the connections are less complicated, and simultaneous explosion is the result; but the slightest disarrangement of the platinum wire in any one charge involves the failure of the whole set, whereas, in the other plan, though the connections are infinitely more numerous, and the current, by being thus desseminated, becomes weaker, yet, though one be defective, it in no way influences the efficiency of the remainder of the set.

The Bickford's fuze was used ultimately to a great extent in firing the mines, and only six failures are recorded of all the charges thus to be exploded; and as these were immersed in water, it is highly probable that they are as much to be attributed to damp affecting the charge as to the failure of the fuze; but the time it takes to burn is so long and so irregular, that nothing like the simultaneous explosion of any set of mines can be expected when they are to be fired thus.

The Bickford's fuze should always be laid in a trough, as jamming it in tamping is very likely to cause it to go out.

The combination of Bickford's fuze and hose is a very excellent method of firing mines though it was scarcely put to a fair test in these operations, but by it an enormous saving of powder hose is effected. The Bickford's fuze is in such short lengths that the explosions are as nearly as possible simultaneous, and an immense deal of trouble is saved in the arrangement of the powder hose, such as bringing it to a focus from a set of charges, &c.; but this mode applies more particularly to a case where a number of charges are exploded through one gallery, as for instance those in the culverts of the docks.

Of powder hose introduced into the charges themselves it is needless to say much, it having been used successfully in numberless operations. Where the galleries and shafts are dry, hose is decidedly the most convenient way of igniting charges; but though great care may be taken in laying the different lengths from the nuclei to the charges, simultaneous action is not so evident as in the case of the charges fired by electricity; and where water exists, the difficulty of making the common linen hose watertight is so great, and success is so precarious, that unless gutta percha tubing can be obtained, I think Bickford's fuze is a preferable agent.

(Signed) EDWARD T. LLOYD, Lieut. Colonel,
Com. Royal Engineer.

10*th March*, 1856.

In transmitting this report I must observe that the powder used was of three different qualities, viz., English, Russian, and Turkish, which must be borne in mind in considering the relative effects of the charges.—E. T. L.

[The following officers of Engineers were employed on the demolition of these docks, under the orders of Lieut. Colonel Lloyd, Commanding Royal Engineer, assisted by Colonel Gordon, C.B., viz. Brevet Major Nicholson, Resident Directing Officer, with Captain C. Cumberland and Lieuts. C. E. Gordon and G. Graham, for about seven weeks, and Lieut. Edwards for the last month only.—Ed.]

APPEND

TABLE SHEWING THE CHARGES OF POWDER

Name of Dock.	Position of Shafts	No. of Shafts	Branches.	Fractional Multiplier of L.L.R.^{3}	Line of Least Resistance	Proposed Charges in lbs.	Charges used, in lbs.	
West Dock	Sides and Ends.	24	North	$\frac{7}{40}$	12′ 7″	348	370	Bi
			South	do.	do.	do.	370	
		23	North	do.	do.	do.	360	
			South	do.	do.	do.	368	
		22	North	do.	do.	do.	384	
			South	do.	do.	do.	377	
		21	North	do.	do.	do.	360	
			South	do.	do.	do.	380	
		28	North	do.	do.	do.	304	
			South	do.	do.	do.	370	
		29	East	do.	do.	334	390	
			West	do.	do.	do.	390	
		67	East *a*	do.	do.	348	377	
			West *b*	do.	do.	do.	370	
		30	North	do.	do.	do.	360	
		9	North	do.	do.	do.	360	
			South	do.	do.	do.	360	
		10	North	do.	do.	do.	366	
			South	do.	do.	do.	388	
		11	North	do.	do.	do.	370	
			South	do.	do.	do.	370	
		12	North 1	do.	do.	do.	350	
			North 2	do.	do.	do.	360	
	Floor of Dock.	44	North	$\frac{3}{20}$	7′ 9″	150	150	
			South	do.	do.	do.	do.	
		51	North	do.	do.	do.	do.	
			South	do.	do.	do.	do.	
		52	North	do.	do.	do.	do.	
			South	do.	do.	do.	do.	
		53	North	do.	do.	do.	do.	
			South	do.	do.	do.	do.	
	Bottom of Entrance	47	South	$\frac{3}{20}$	10′ 0″	500	500	
	Sides of Entrance	69	*a*	$\frac{3}{20}$	13′ 0″	330	400	B f
			b	do.	do.	do.	do.	
			c	do.	do.	do.	do.	
		68	*a*	do.	do.	do.	do.	
			b	do.	do.	do.	do.	
			c	do.	do.	do.	do.	

R II.

OLITION OF THE DOCKS AT SEBASTOPOL.

ranches.	Wet or Dry.	Success.	Effect.	REMARKS.
North	Dry	Exploded	Partial	1.—The charges in 24, 23, 22, 21, 28, 29 67, 30, 9, 10, 11, and 12, were to be fired by the wires, but Bickford's fuze had been attached to all except 67 *a* and *b*, and the charges in 23 ; the wires however failed, and 16 of the 23 exploded by the ignition of the fuze. 2.—Partial, in the column for "Effect," implies that, in this case, though the revetment was brought down, a portion of the lower step remained. 3.—Both charges in No. 28 blew out through the made earth behind the revetment. 4.—Fresh charges were placed in the situations where Nos. 24, 23, 22, 67 *a* and *b*, and 30, missed. (Vide the end of the table). 5.—The additions to the charges were made on account of the galleries being too short. 6.—The failure in the Bickford's fuze was most probably owing to damp, except in 24.
South	do.	Failed		
North	Very wet	do.		
South	do.	do.		
North	Wet	do.		
South	do.	Exploded	Partial	
North	do.	do.	Complete	
South	do.	do.	do.	
North	do.	do.	Blew out behind the wall	
South	do.	do.		
East	Dry	do.	Complete	
West	do.	do.	do.	
East *a*	Very wet	Failed		
West *b*	do.	do.		
North	Wet	do.		
North	Dry	Exploded	Complete	
South	do.	do.	do.	
North	do.	do.	Partial	
South	do.	do.	do.	
North	do.	do.	do.	
South	do.	do.	Complete	
North 1	do.	do.	Partial	
North 2	do.	do.	do.	
orth	Very wet	Exploded	Complete	1.—All these charges were connected in one set with the batteries, the current being passed through them consecutively. 2.—All the mines were surcharged ; the craters were thus exaggerated, but did not quite meet.
outh	do.	do.	do.	
orth	do.	do.	do.	
outh	do.	do.	do.	
orth	do.	do.	do.	
outh	do.	do.	do.	
orth	do.	do.	do.	
outh	do.	do.	do.	
orth	Very wet	Exploded	Complete	Charge enormously increased on account of the resistance of the frame-work and gates closed on it.
a	Dry	Exploded	Complete	1.—The cause of failure in 68 *b* is unexplained, but the craters made by 68 *a* and *c* so nearly met that only a small portion of the wall remained, which was afterwards brought down by a small charge. 2.—Charges increased on account of the resistance of the gates, and placed in chambers cut in the sides of feeder drains.
b	do.	do.	do.	
c	do.	do.	do.	
a	do.	do.	do.	
b	do.	Failed		
c	do.	Exploded	Complete	

TABLE Shewing the Charges of Powder

Name of Dock.	Position of Shafts	No. of Shafts	Branches.	Fractional Multiplier of L.L.R.^{3}	Line of Least Resistance	Proposed Charges in lbs.	Charges used, in lbs.
Centre Dock	Sides and Ends.	7	North	$\frac{7}{40}$	12′ 9″	363	370
			South	do.	do.	do.	do.
		6	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		5	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		8	North	do.	do.	do.	do.
			South	do.	do.	do.	460
		31	South	do.	do.	do.	400
		32	East	do.	12″ 11″	384	390
			West	do.	do.	do.	do.
		64	East *a*	do.	12′ 9″	363	370
			West *b*	do.	do.	do.	do.
		1	South 1	do.	do.	do.	do.
			South 2	do.	do.	do.	do.
			North	do.	do.	do.	do.
		2	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		3	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		4	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
	Floor of Dock.	43	North	$\frac{3}{20}$	7′ 9″	160	160
			South	do.	do.	do.	do.
		54	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		55	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		56	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		57	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		58	North	do.	do.	do.	do.
	Sides of Entrance.	66	*a*	$\frac{3}{20}$	13′ 0″	330	400
			b	do.	do.	do.	do.
			c	do.	do.	do.	do.
		65	*a*	do.	do.	do.	do.
			b	do.	do.	do.	do.
			c	do.	do.	do.	do.
	Bottom of Entrance.	46	North	$\frac{1}{5}$	12′ 7″	300	380
			South	do.	do.	do.	do.

MOLITION OE THE DOCKS AT SEBASTOPOL.

Branches	Wet or Dry.	Success.	Effect.	Remarks.
North	Wet	Exploded	Partial	1.—The charges in this dock, with exception of No. 31, destroyed the whole of the bottom steps; but portions of the work were left standing above the upper wall.
South	do.	do.	Complete	
North	do.	do.	do.	
South	do.	do.	do.	
North	Dry	do.	do.	
South	do.	do.	do.	
North	do.	do.	do.	
South	do.	do.	do.	
South	Wet	do.	Partial	2.—In No. 31, though the charge exploded, the only effect it produced was to loosen the joints of the masonry; but no part of the wall was brought down. A portion of the charge must have become damp.
East	Dry	do.	Complete	
West	do.	do.	do.	
East *a*	Wet	do.	do.	
West *b*	do.	do.	do,	
South 1	do.	do.	do.	
South 2	do.	Doubtful		
North	do.	Exploded	do.	
North	do.	do.	Complete	
South	do.	do.	do.	Nos. 1, 2, 3, and 4, (nine mines) were connected with the batteries by "crow's feet" in one set.
North	do.	do.	do.	
South	do.	do.	do.	
North	do.	do.	do.	
South	do.	do.	do.	
North	Very wet	Exploded	Complete	
South	do.	do.	do.	1.—The thirteen charges in the floor of that dock and of the entrance were connected in two sets with the batteries.
North	do.	do.	do.	
South	do.	do.	do.	
North	do.	do.	do.	
South	do.	Doubtful		
North	do.	Exploded	Complete	2.—Only one keel-block in the centre of the dock remained intact after the explosion.
South	do.	do.	do.	
North	do.	do.	do.	
South	do.	do.	do.	
North	do.	do.	do.	
a	Dry	Exploded	Complete	1.—Nos. 66 *b* and *c* failing, the gallery was driven from the chain hole above, for the effect of which vide end of table.
b	do.	Failed		
c	do.	do.		
a	do.	Exploded	Complete	
b	do.	do.	do.	2.—The current of electricity passed through 65 *a*, *b* and *c*, in succession.
c	do.	do.	do.	
North	Very wet	Exploded	Partial	Both these charges blew out to the north of the frame work, completely destroying the stone-work, but leaving the frame intact.
South	do.	do.	do.	

TABLE SHEWING THE CHARGES OF POWDER

Name of Dock	Position of Shafts	No. of Shafts	Branches.	Fractional Multiplier of $L.L.R.^3$	Line of Least Resistance	Proposed Charges in lbs.	Charges used, in lbs.
East Dock	Sides and Ends	16	North	$\frac{7}{40}$	12′ 11″	384	450
			South	do.	do.	do.	do.
		15	North	do.	do.	do.	390
			South	do.	do.	do.	450
		14	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		13	North	do.	do.	do.	do.
			South 1	do.	do.	do.	390
			South 2	do.	do.	do.	do.
		61	West *a*	do.	do.	do.	450
			East *b*	do.	do.	do.	do.
		35	East	do.	do.	do.	390
			West	do.	do.	do.	do.
		17	South 1	do.	do.	do.	480
			South 2	do.	do.	do.	do.
			South 3	do.	do.	do.	do.
			North	do.	do.	do.	do.
		18	North	do.	do.	do.	460
			South	do.	do.	do.	do.
		19	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		20	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
	Floor of Dock.	42	North	$\frac{3}{20}$	10′ 3″	160	160
			South	do.	do.	do.	do.
		56	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		49	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		48	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		59	North	do.	do.	do.	do.
			South	do.	do.	do.	do.
		60	North	do.	do.	do.	do.
	Bottom of Entrance	45	East	$\frac{3}{20}$	12′ 7″	300	400
			West	do.	do.	do.	do.
			North	do.	do.	do.	300
	Sides of Entrance	63	*a*	$\frac{3}{20}$	13′ 0″	330	340
			b	do.	do.	do.	do.
			c	do.	do.	do.	do.
		62	*a*	do.	do.	do.	do.
			b	do.	do.	do.	do.
			c	do.	do.	do.	do.

DEMOLITION OF THE DOCKS AT SEBASTOPOL.

Branches.	Wet or Dry.	Success.	Effect.	REMARKS.
North	Wet	Exploded	Complete	1.—Nos 16 and 15 south, 14 and 13 north, and 61 *a* and *b* were all to have been fired off by the wires, but these failing, the charges were untamped, Bickford's fuze was attached, and a bag of powder added to each charge. 2.—The lower steps were completely destroyed, but here and there portions of the wall above the upper step remained standing. 3.—Owing to there being no tamping in the culvert, the charges in Nos. 17, 18, 19, and 20 were all increased by about 80 lbs. 4.—The failure in No. 18 south was occasioned by the wires being destroyed by the premature discharge of the charges in No. 17, by which the charges in Nos. 18, 19, and 20 were to have been fired.
South	do.	do.	do.	
North	do.	do.	do.	
South	do.	do.	do.	
North	Dry	do.	do.	
South	do.	do.	do.	
North	do.	do.	do.	
South 1	do.	do.	do.	
South 2	do.	do.	do.	
West *a*	Very wet	do.	do.	
East *b*	do.	do.	do.	
East	Dry	do.	do.	
West	do.	do.	do.	
South 1	Wet	do.	do.	
South 2	do.	do.	do.	
South 3	do.	do.	do.	
North	do.	do.	do.	
North	do.	do.	do.	
South	do.	Failed		
North	do.	Exploded	Complete	
South	do.	do.	do.	
North	do.	do.	do.	
South	do.	do.	do.	
North	Very wet	Exploded	Complete	1.—Nos. 42, 56, 49, 48, and 58 (ten mines) were fired in two sets by " crow's feet." 2.—The failure in 42 was most probably owing to damp, as was proved to be the case in 59, on removing the charges from that mine. 3.—The charges were again placed in 59, and were fired at the same time as the single charge in 60, the current being passed through the set.
South	do.	Doubtful	Blew through the tamping	
North	do.	Exploded	Complete	
South	do.	do.	do.	
North	do.	do.	do.	
South	do.	do.	do.	
North	do.	do.	do.	
South	do.	do.	do.	
North	do.	Failed		
South	do.	do.		
North	do.	Exploded	Complete	
East	Very wet	Exploded	Partial	These three charges were fired together, the current passing through these consecutively, though once there was a little doubt about 45 east. The destruction of the framing was complete.
West	do.	do.	Complete	
North	do.	do.	do.	
a	Dry	Exploded	Complete	Fired by wires at different times ; at the first time only 63 c went off; 63 *a* and *b*, were however afterwards connected and discharged simultaneously.
b	do.	do.	do.	
c	do.	do.	do.	
a	do.	Failed		No. 62 *a* and *b*, first intended to be fired by wires, failed. Hose was then laid down to the charges, and they were successfully exploded.
b	do.	do.		
c	do.	Exploded	Complete	

TABLE Shewing the Charges of Powder used

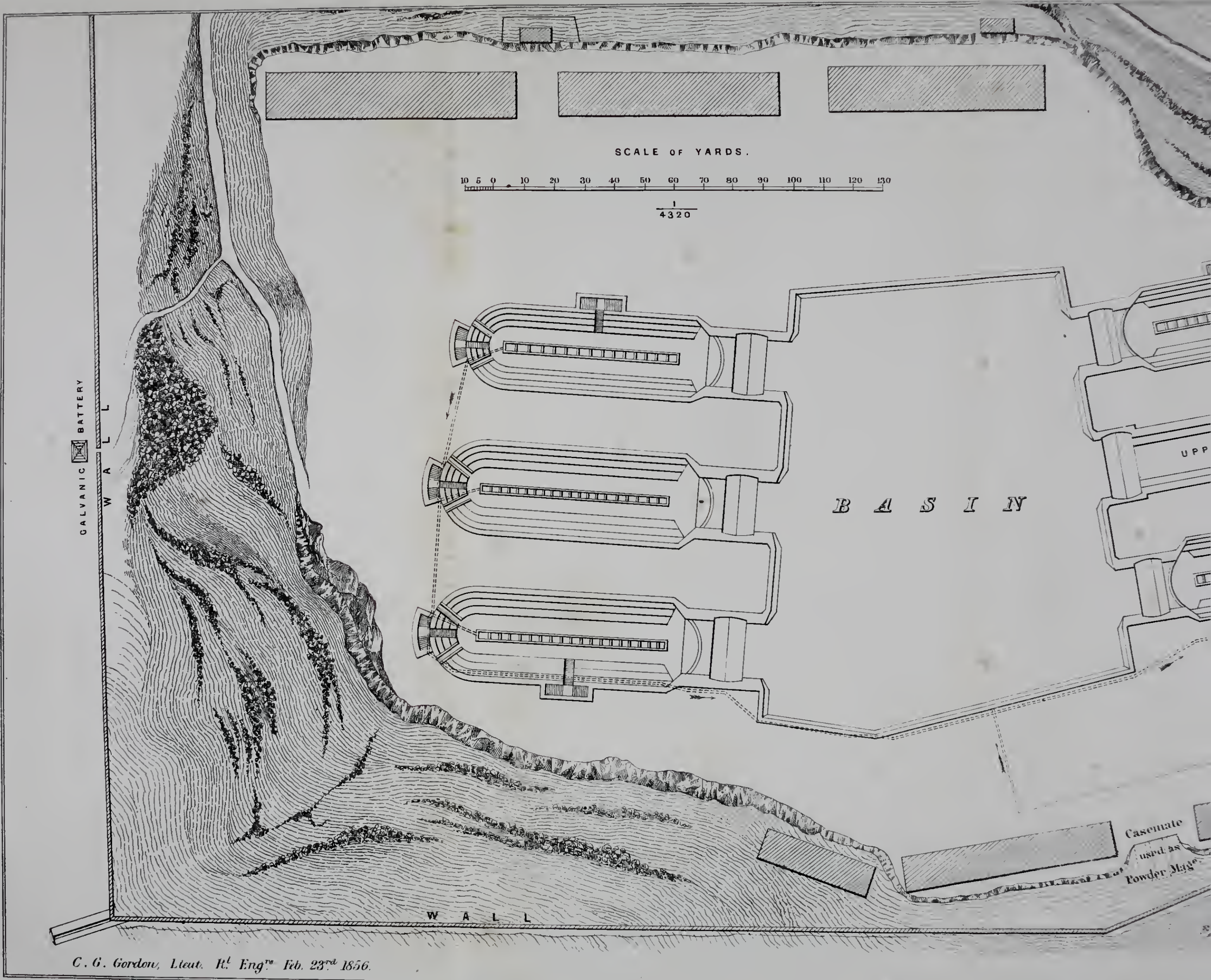
Name of Dock.	Position of Shafts	No. of Shafts	Branches.	Fractional Multiplier of L.L.R.^{3}	Line of Least Resistance	Proposed Charges in lbs.	Charges used, in lbs.	Means Firing.
Basin Wall.	West.	27a	North	$\frac{3}{20}$	6′ 6″	42	60	Bickford's
			South	do.	7′ 6″	64	80	do.
		27	North	do.	do.	do.	do.	do.
			South	$\frac{1}{5}$	do.	do.	do.	do.
		26	North	$\frac{3}{20}$	do.	do.	do.	do.
			South	do.	do.	do.	do.	do.
		25	North	$\frac{1}{5}$	do.	do.	do.	do.
		25a	North	$\frac{3}{20}$	do.	do.	do.	do.
			South	do.	do.	do.	do.	do.
		69a	West	$\frac{1}{5}$	11′ 3″	280	320	Fuze & h
	East.	39	North 1	$\frac{1}{5}$	10′ 0″	200	260	Wires.
			North 2	do.	8′ 3″	112	160	do.
			South 1	do.	do.	do.	do.	do.
			South 2	do.	10′ 3″	200	260	do.
		38	North 1	do.	do.	do.	do.	do.
			North 2	do.	11′ 9″	320	400	do.
			South 1	do.	9′ 8″	122	170	do.
			South 2	do.	do.	do.	do.	do.
			South 3	do.	do.	do.	do.	do.
			South 4	do.	11′ 3″	280	320	do.
	End of Pier between West and Centre Docks	70		$\frac{1}{5}$	17′ 0″	800	820	Wires.
	End of Pier between East and Centre Docks	63a	West	$\frac{1}{5}$	17′ 0″	800	820	Wires.
Charges Lodged subsequently to Failures.		46	East		8′ 6″	200	200	Wires
			West		do.	do.	do.	
	Chain hole, West side of Entrance.		West		14′ 0″	411	450	B. Fuz
				Length of branches.				
		24	South	4′ 0″	19′ 0″	300	300	Hose
		23	North	9′ 0″	12′ 0″	300	300	do.
			South	15′ 0″	do.	310	320	do.
		28	North	7′ 6″	do.	300	300	do.
			South	15′ 6″	do.	400	400	do.
		30	North	8′ 0″	do.	300	300	do.
			South	15′ 0″	do.	400	400	do.
		59	North		10′ 3″	160	160	Wires
			South		do.	do.	do.	do.

DEMOLITION OF THE DOCKS AT SEBASTOPOL.

f s.	Branches.	Wet or Dry.	Success.	Effect.	REMARKS.
	North	Dry	Exploded	Complete	1.—Though all the charges placed in the West Basin wall were very much increased, with one exception, viz., 69 *a*, they gave evidence of their not being sufficient. 2.—The number of counterforts was not accurately ascertained, the consequence of which error was that every alternate counterfort remained; they were however destroyed by small charges afterwards. 3.—No. 69 *a* was fired at a period subsequent to the remainder of the charges in the wall, and it was increased on account of its situation in a re-entering angle.
	South	do.	do.	Partial	
	North	do.	do.	Complete	
	South	do.	do.	do.	
	North	do.	do.	Partial	
	South	do.	do.	Complete	
	North	do.	Failed		
	North	do.	Exploded	Partial	
	South	do.	do.	do.	
	West	do.	do.	Complete	
	North 1	Wet	Exploded	Complete	1.—All the charges in 38, 39, and 62 *a* and *b*, were to have been fired in two sets of six each, the current passing through each charge consecutively, but owing to the set in 38 exploding before that in 39, the connection in the latter was destroyed; the charges were therefore untamped, and hose being attached to them they were successfully fired. 2.—These charges were increased on account of the deficiency of tamping.
	North 2	do.	do.	do.	
	South 1	do.	do.	do.	
	South 2	do.	do.	do.	
	North 1	do.	do.	do.	
	North 2	do.	do.	do.	
	South 1	do.	Failed		
	South 2	do.	do.	do.	
	South 3	do.	do.	do.	
	South 4	do.	do.	do.	
		Dry	Exploded	Complete	This charge was increased because it was placed in so many different cases.
	West	Dry	Exploded	Complete	
6	East	Very wet	Exploded	Complete	These charges were placed on account of the failure of the original mine.
	West	do.	do.	do.	
hole ide ice	West	Dry	Exploded	Complete	This charge was required on account of the failure of 46 *a* and *b*.
	South	Dry	Exploded	Complete	All these charges completed the destruction of such portions of the revetment of the West Dock as remained, owing to the failures in the original mines bearing these numbers.
	North	do.	do.	do.	
	South	do.	do.	do.	
	North	do.	do.	do.	
	South	do.	do.	do.	
	North	do.	do.	do.	
	South	do.	do.	do.	
	North	Very wet	Exploded	Complete	The original charges in this shaft having failed from damp these were placed to destroy the portions of the floor remaining above them.
	South	do.	do.	do.	

Abstract of Total Amount of Powder Expended in the Demolition of the Docks.

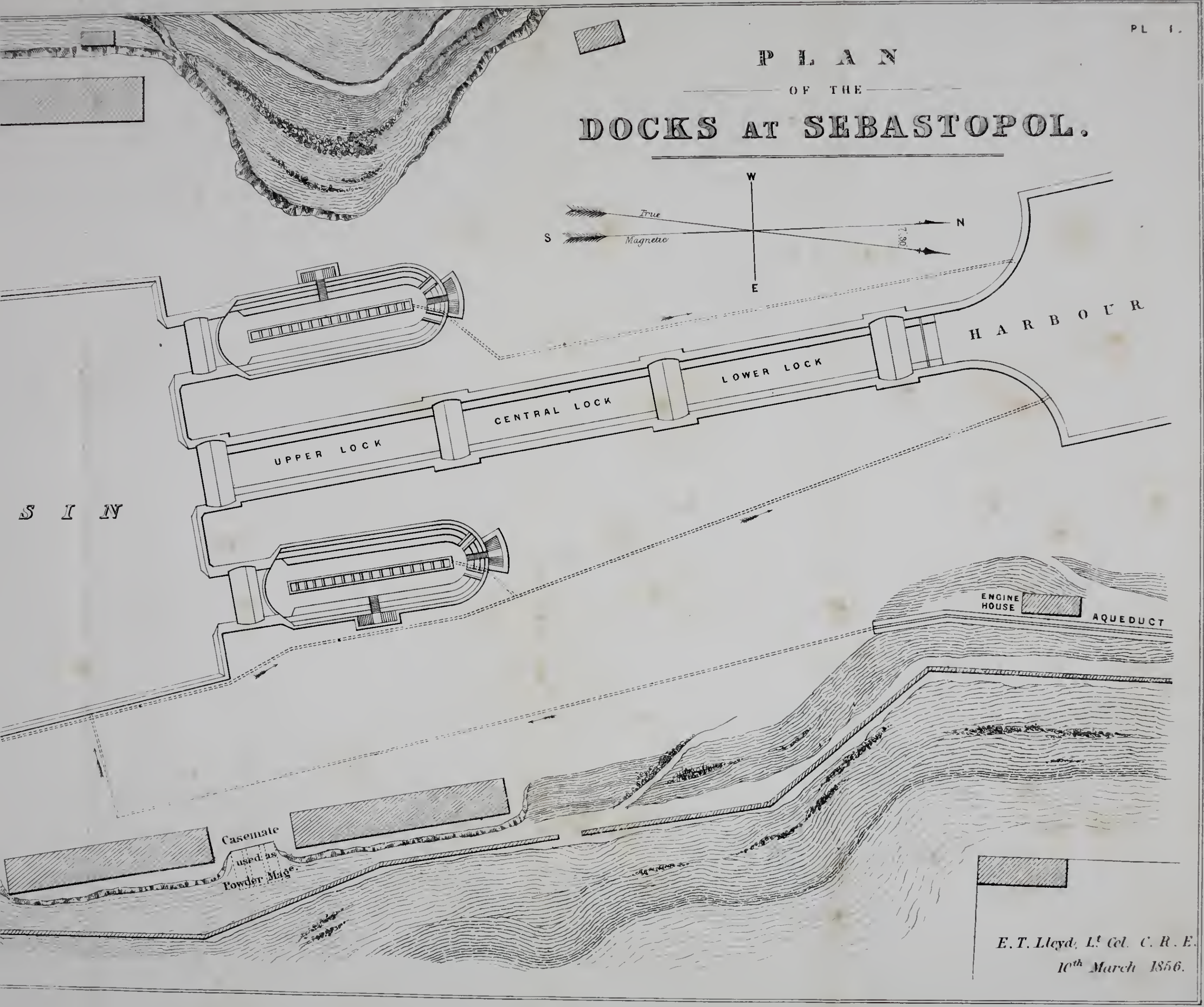
		lbs.	
West Dock	23 original charges in the revetments	8,454	
	7 additional charges in ditto, caused by failures	2,320	
	8 charges in floor	1,200	
	1 charge under the sill of the entrance	500	
	6 charges in the sides of ditto	2,400	
	Total of West Dock		14,874
Centre Dock	22 original charges in the revetments	8,300	
	11 charges in floor	1,760	
	6 charges in sides of entrance	2,400	
	1 extra, on account of failure in ditto	450	
	2 charges under the sill	760	
	2 extra charges in same position	400	
	Total of Centre Dock		14,070
East Dock	23 original charges in the revetments	10,230	
	11 charges under the floor	1,760	
	2 extra charges under the floor	320	
	6 charges in sides of entrance	2,040	
	3 charges under the sill	1,100	
	Total of East Dock		15,450
Basin	10 charges in the West Basin wall	1,020	
	10 charges in the East Basin wall	2,330	
	2 charges at the ends of the piers between the Docks	1,640	
	Total of Basin wall		4,990
	Grand total in lbs.		49,384



C. G. Gordon, Lieut. Rl. Engrs. Feb. 23rd 1856.

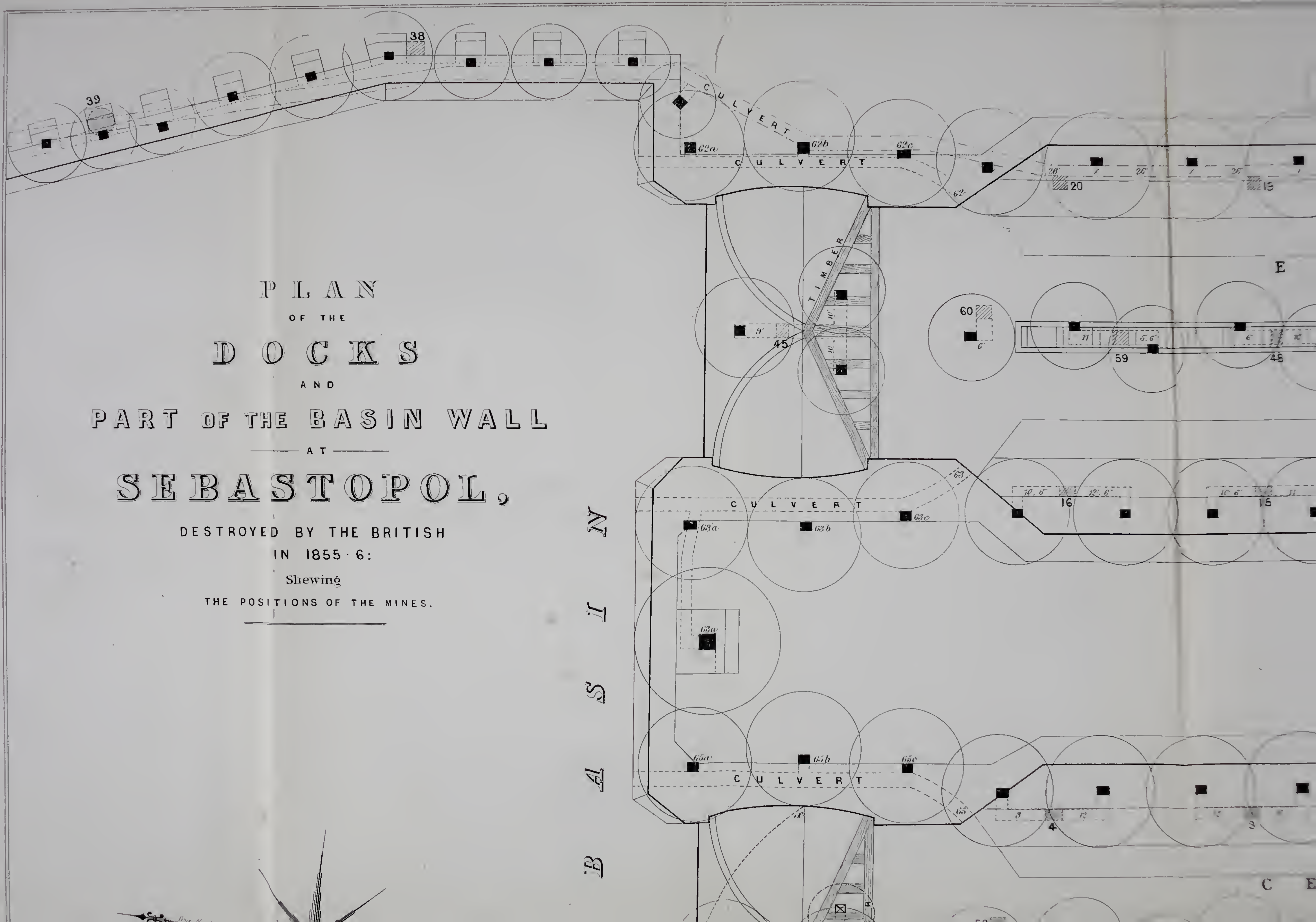
PL 1.

PLAN OF THE DOCKS AT SEBASTOPOL.



E. T. Lloyd, Lt. Col. C. R. E.
10th March 1856.

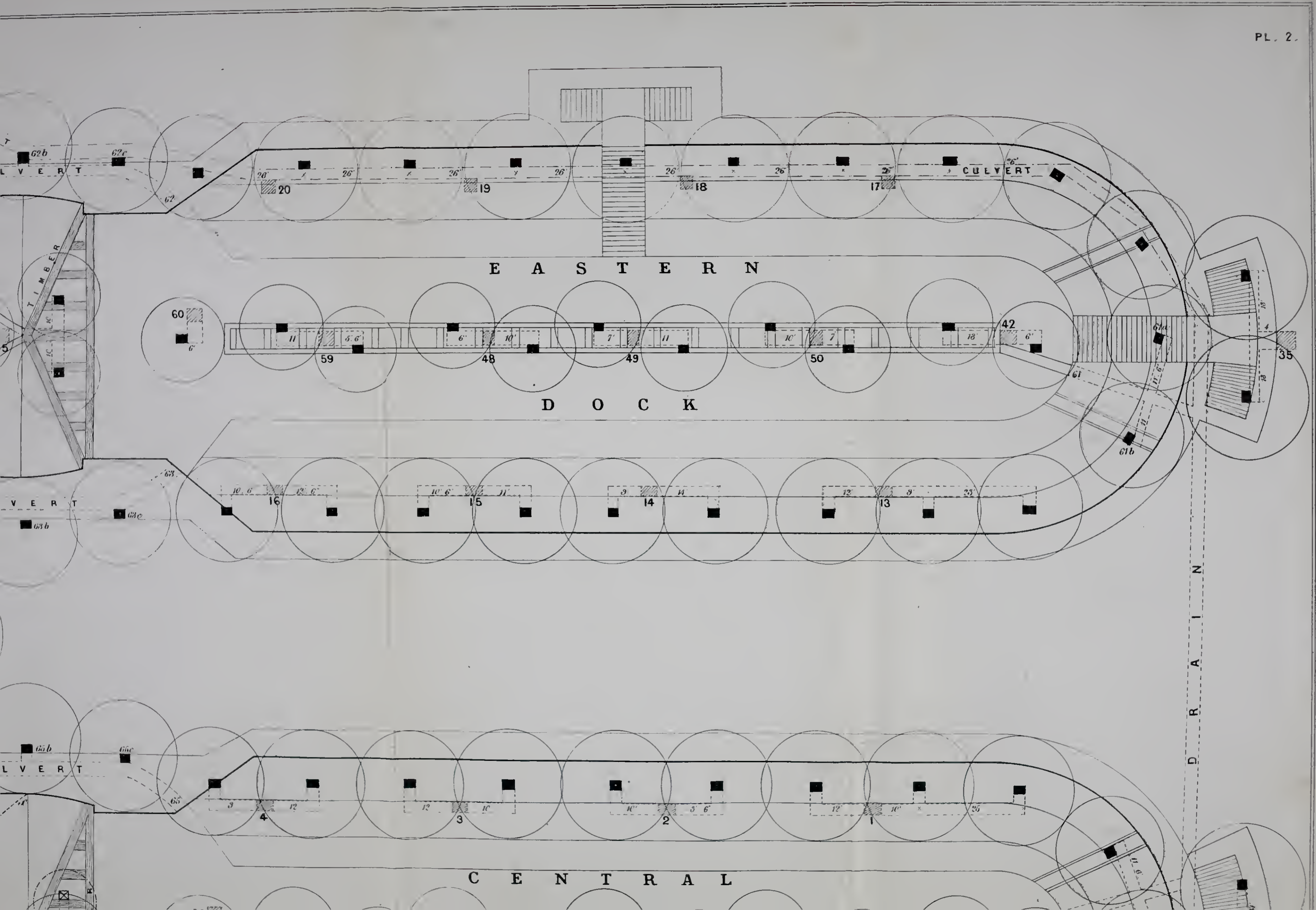
C Moody Lith, 257, Holborn, London



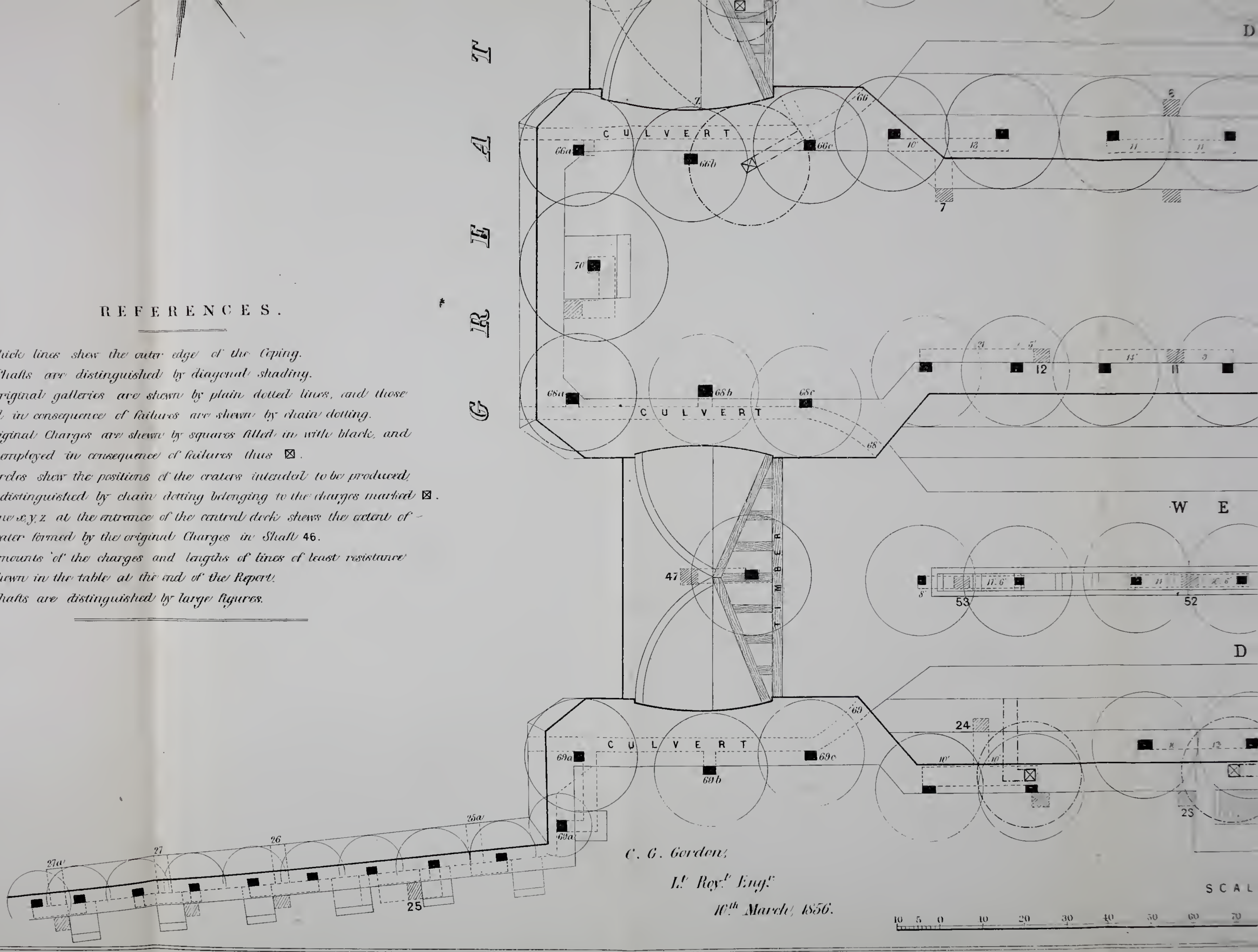
PLAN
OF THE
DOCKS
AND
PART OF THE BASIN WALL
AT
SEBASTOPOL,

DESTROYED BY THE BRITISH
IN 1855·6;
Shewing
THE POSITIONS OF THE MINES.

PL. 2.



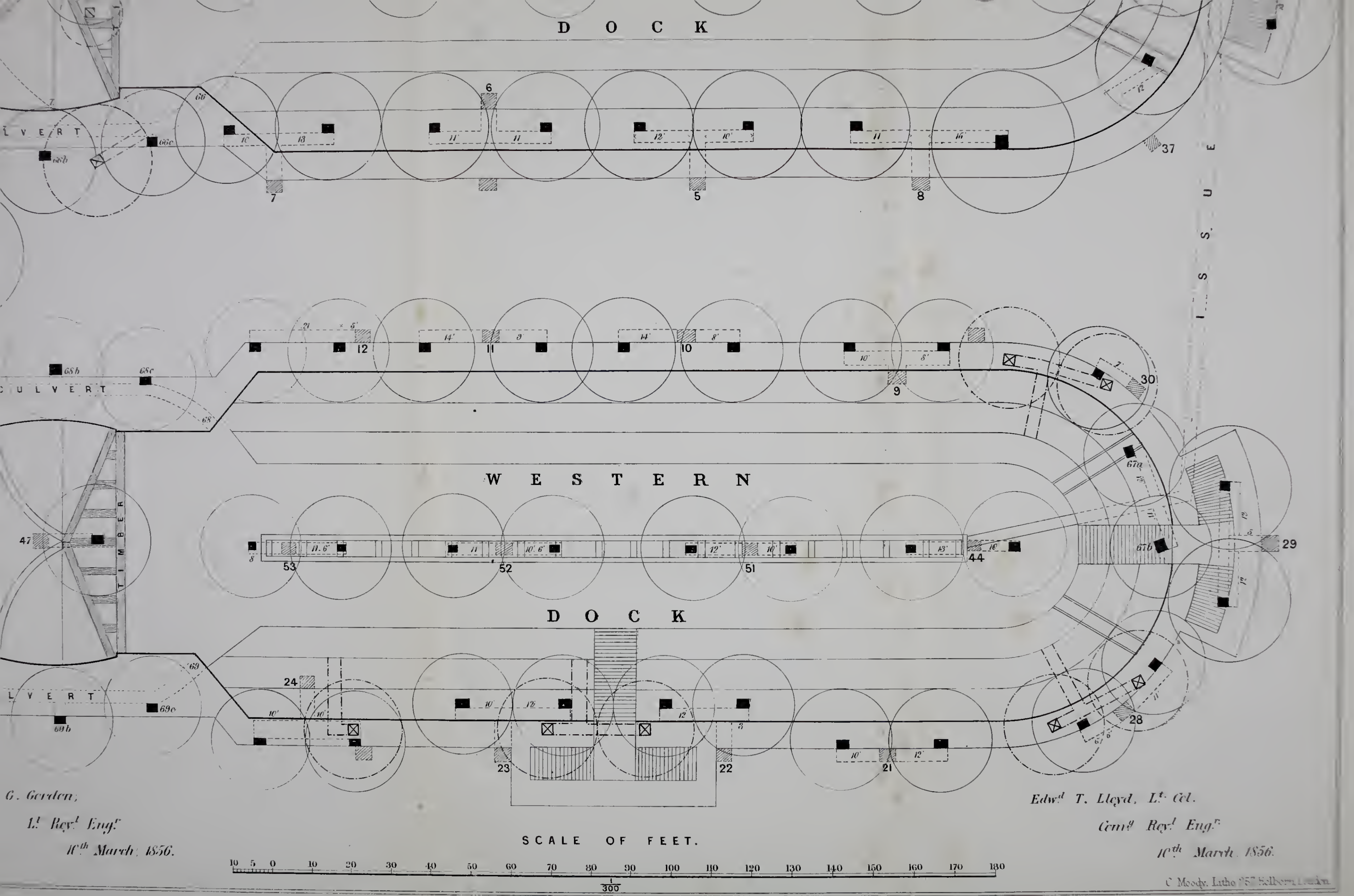
EASTERN
DOCK
CENTRAL
CULVERT
CULVERT
CULVERT
CULVERT
TIMBER
DRAIN



REFERENCES.

The thick lines shew the outer edge of the Coping.
The Shafts are distinguished by diagonal shading.
The original galleries are shewn by plain dotted lines, and those formed in consequence of failures are shewn by chain dotting.
The original Charges are shewn by squares filled in with black, and those employed in consequence of failures thus ☒.
The circles shew the positions of the craters intended to be produced, those distinguished by chain dotting belonging to the charges marked ☒.
The line x, y, z at the entrance of the central dock shews the extent of the Crater formed by the original Charges in Shaft 46.
The amounts of the charges and lengths of lines of least resistance are shewn in the table at the end of the Report.
The Shafts are distinguished by large figures.

C. G. Gordon,
Lt Roy.l Eng.s
10th March, 1856.



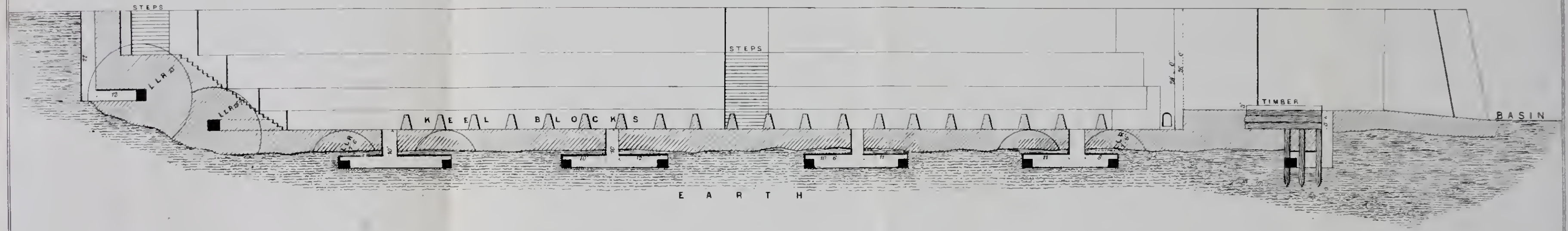
G. Gordon,
Lt Royl Engr
10th March 1856.

Edwd T. Lloyd, Lt Col.
Comg Royl Engr
10th March 1856.

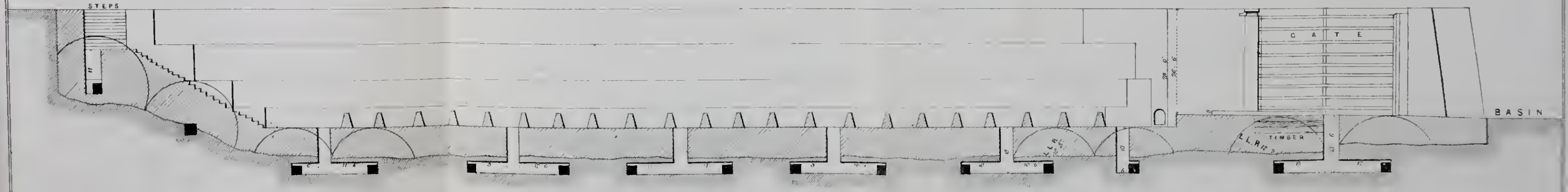
C. Moody, Litho 257 Holborn London.

DEMOLITION OF DOCKS
AT
SEBASTOPOL
BY THE BRITISH.

LONGITUDINAL SECTION THROUGH WESTERN DOCK.

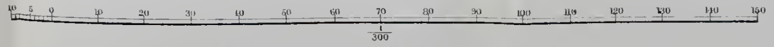


LONGITUDINAL SECTION THROUGH CENTRAL DOCK.



C. G. Gordon,
Lt Rl Engineers,
Feb. 28th 1856

SCALE OF FEET

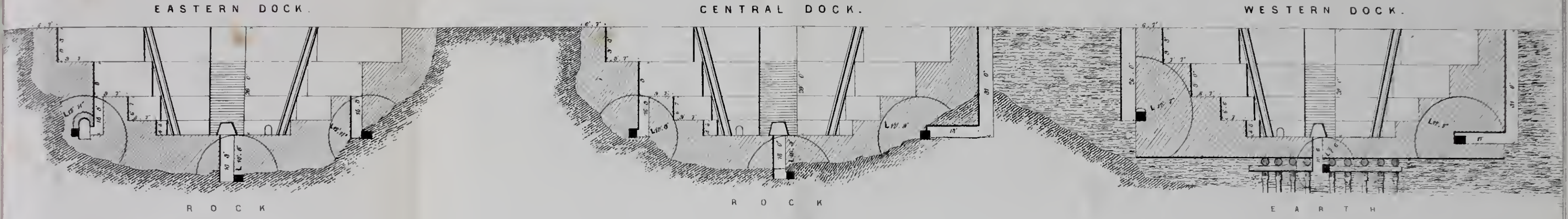


Note. *The charges are shown in black & the masonry is distinguished by diagonal shading.*

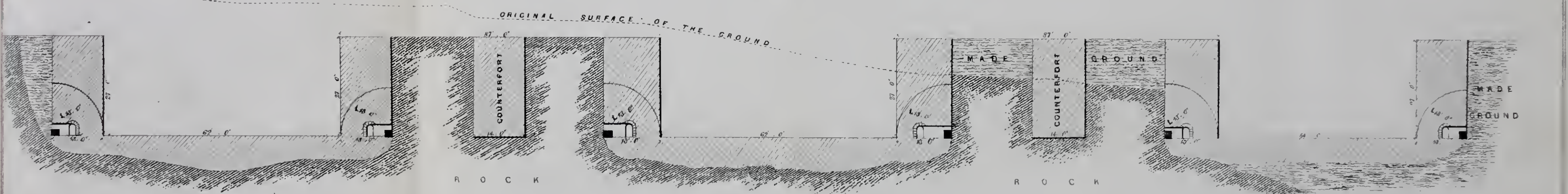
Edwd T. Lloyd, Lt Col.
Comd Rl Engrs
10th March 1856

DEMOLITION OF DOCKS AT SEBASTOPOL
BY THE BRITISH.

TRANSVERSE SECTION THROUGH THE DOCKS.

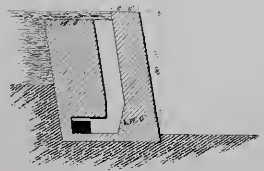


SECTION THROUGH THE PIER HEADS.



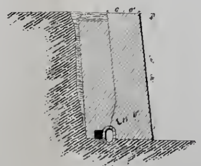
PIER BETWEEN WEST & CENTRE DOCKS.

SECTION THROUGH COUNTERFORT.

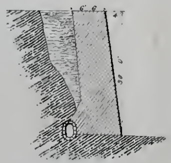


EAST WALL OF BASIN.

SECTION THROUGH COUNTERFORT.

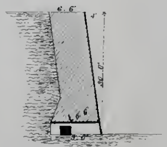


SECTION THROUGH WALL.

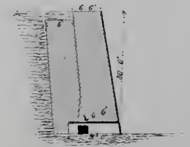


WEST WALL OF BASIN.

SECTION THROUGH WALL.



SECTION THROUGH COUNTERFORT.



C. G. Gordon,
Lt. Rl. Engineers,
February 28th 1856.

Note. *The numbers preceded by the letter L are the lengths of the lines of least resistance.*
The charges are shewn in black, and the masonry is distinguished by diagonal shading

SCALE OF FEET.

10 5 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

1/300

Edwd. T. Lloyd, Lt. Col.
Comg. Rl. Engineer;
10th March, 1856.

C Moody Lith 257 Holborn London

PAPER III.

REPORT ON THE DEMOLITION OF THE WHITE BUILDINGS AT SEBASTOPOL.

BY LIEUTENANT GRAHAM, R.E.

Head Quarters, Sebastopol,
April 4th, 1856.

The White Buildings collectively form a rectangle of 400 yards from north to south, by about 200 yards from east to west.

The north and south sides of this rectangle consist of two buildings, precisely alike, which are called in this Report the north and south ranges.

They are each 582 feet long, and 50 feet in mean breadth, having three stories, and being furnished with underground vaults and cellars. (Plate 1.)

Each building had four vaults, in each of which was a heating apparatus, from whence, by means of flues, the hot air was led into the rooms above.

In the north range, the fires of these vaults were supplied with fresh air by galleries leading to two ventilators situated 30 yards in front of the north face of the building.

The ventilators were handsomely built in masonry, about 16 feet square, and rose 12 feet above the ground, each being surmounted by a small columned cupola, containing the radiating wooden wind-sails for catching the air.

The north and south ranges appear to have been of more recent erection than the other buildings, and were superior in construction, the bonding of the walls being remarkably perfect.

Previous to the demolition, the roof of the west range was nearly complete, as were also the flooring joists; but all the timber of the south range had been burnt.

The west side of the rectangle of the White Buildings is formed by two long ranges, two stories in height.

Under the north end of the southern building there were arched vaults.

The woodwork of the northern building had been removed, except the ceiling joists over the passages; the roof of the southern one, however, remained almost entire.

Two rows of pillars ran along the entire length of the building, and carried part of the roof, and the upper floor; these buildings are of older construction than the north and south ranges, and the masonry and mortar are inferior.

The north, south, and west ranges appear to have been used as barracks.

All the outbuildings are placed on the east side, and are one story in height. The principal buildings are at the centre of the east side, and form a rectangle of about 100 by 80 yards; these buildings have been used as kitchens, offices, &c.

The clock tower stood over an arched entrance. (A, Plate 1.)

The building marked B (Plate 1) was a large kitchen with arched cellars underneath. (For details of construction see Figs. 8, 9, 10, Plate 4.)

The remainder of the buildings were of little importance, and nearly all the woodwork had been removed from them.

The demolitions effected were confined to the north, south, and west ranges, and the central buildings.

The exterior walls of the great buildings of the north and west ranges were left standing by special order, to form a screen to working parties employed in collecting timber.

The walls of the south range were much damaged by shot, and the wood-work having been burnt, it was not considered necessary to demolish them entirely.

EXPERIMENTS.

A few preliminary experiments were made by Major Ranken for the purpose of ascertaining the best and speediest method of effecting the demolition.

The first experiment tried was that of demolishing a part of the outer wall of the south range, by blasting the window piers; (January 30th and 31st, and February 1st.) For this purpose 1⅛″ jumper holes were made, one on each side of the window piers, and 3 feet 10 inches deep. (See Plate 2, Figs. 12 and 13).

The walls were 4 feet thick, giving a line of least resistance of 2 feet.

Charges of ¼ L.L.R^3, or 2 lbs., were used, occupying 26 inches of a hole 1¾″ in diameter.

For the dead walls, × holes[*] were made, the same as the others, and were placed at 2½ lined intervals, or 5 feet apart.

The demolition effected in this manner by 38 charges was tolerably successful. A portion of the west side at the angle being left in a tottering state, was brought down by a bag of powder containing about 20 lbs. Owing to the loose building of the walls of the west range, Major Ranken found it preferable, in after practice, to make the angle holes 4′ 6″ deep, with charges of 2½ lbs.

The second experiment tried (February 4th) was placing 15 charges of 48 lbs. on the ground at the centres of the window piers, being at 2½ lined intervals, or 10 feet apart. (Figs. 1 and 2, Plate 2.)

Tamping about 5 feet thick was obtained from a trench dug in rear. The demolition was essentially *hasty*, the whole of the preparations being made easily in five hours.

The demolition was successful, but violent, the tamping, stones, &c. being blown out to a a considerable distance; a wall 160 feet long was thus destroyed. (Figs. 1 and 2, Plate 2.)

At the same time 10 charges of 25 lbs. were placed along 100 feet of the exterior wall, including a small return of dead wall 36 feet long; the charges were placed in chambers made in the wall, at the bottom of a trench; (Figs. 3 and 4, Plate 2.) The whole was securely tamped with earth and solid shot. The effect of this was to bring down the greater part of the wing of the building against which the charges were placed; but the return of dead wall remained standing, the charges having blown holes through it without bringing it down. (Figs. 3 and 4, Plate 2.)

In the former experiment with 48 lb. charges, the mines were brought to three foci, but in the latter they were fired by separate pieces of Bickford's fuze.

The next experiment tried by Major Ranken, on the exterior walls of the south range, was to sink a trench 3 feet deep along the face of the wall, in which 25 lb. charges were placed opposite to the centres of the window piers and in the dead walls, at two lined intervals; the hose in this instance was led from one charge to the others; the tamping was 4′ thick; (Figs. 5 and 6, Plate 2.) The hose was ignited at three points by Bickford's fuze, but one half of the charges were not fired, owing to the rupture of the connecting hose; the number of the charges was 46; the wall was greatly shaken, but not brought down.

---

[*] These were formed by boring holes with a jumper from each side of the wall, inclined downwards so as to intersect in the centre.—ED.

To complete the demolition, shafts were sunk the next day (February 12th), about 3′ 6″ deep, at the centres of the window piers from the inside, where the previous explosions had blown out the tamping, and were loaded with charges of 25 to 30 lbs, (Fig. 7, Plate 2,) and by firing the other unexploded charges of the day before, the remaining part of the wall was brought down.

Two days previous to the last detailed experiment (February 9th) one of the vaults of the south range was demolished by nine charges of 100 lbs. each, placed as shewn in the accompanying sketch. (Figs. 8, 9, 10, Plate 2.)

The vault was entirely demolished, and the adjacent main walls were considerably shaken; part of a partition wall was thrown down; the stones were not much scattered.

North Range.

The following were the preparations made for the demolition of the north range of buildings.

In the portions of the exterior wall opposite to the long rooms, where the ground is at the same level inside as outside, the charges were placed 3 feet below the surface of the ground, the chambers being previously built up with stones, and backed with loose earth. (Fig. 7, Plate 3.)

A trench 3 feet deep, (Fig. 4, Plate 3) was also dug on the interior side of the wall so as to diminish the resistance.

These charges were of 30 lbs., or nearly ½ L.L.R^3, the wall being 4 feet thick; and they were all placed in the centres of the window piers, at a mean distance of 10 feet apart.

For the demolition of the partition walls of the rooms, which were 3 feet thick, charges of 15 lbs., or about half L.L.R^3, were placed at two lined intervals along the walls, charges of 30 lbs. being lodged at the re-entering angles.

Tamping of earth and stones, 5 feet thick, was placed over each charge. (Figs. 4 and 5, Plate 3.

There were, as before mentioned, 4 vaults in the north range; over the vaults and adjoining them were the cellars, the level of the pavement of which averages 5′ 6″ below the ground outside.

Shafts 4′ 6″ deep were made along the exterior walls of these cellars, and placed like the rest opposite the centres of the window piers, (Fig. 3, Plate 3): altogether there were 82 charges in the south exterior wall; this includes 8 charges of 50 lbs. each, placed in the re-entering angles; the tamping for all these charges was from 8 to 9 feet thick, and well rammed.

In the cellars, on each side of each vault, shafts were sunk, 8 feet apart, to depths of 4′ 6″ and 5′ 6″. (Figs. 1 and 2, Plate 3.)

There were 11 charges for each vault, six on one side and five on the other, of 50 lbs. each; they had lines of least resistance of four feet to the soffits of the arches of the vaults, and were intended for the destruction of the vaults and of the partition walls above them.

Those for the south face and interior walls were brought to a focus on each wing, and those of the partition walls and vaults to one focus in each room.

For the demolition of the two outside ventilators, a shaft was first sunk into the ventilating gallery from the south side, and four charges of 50 lbs. were lodged in the angles of each ventilating shaft, the tamping being composed of timber strutting. (Fig. 11, Plate 2).

The north walls and gable walls of the north range were all prepared for demolition with considerable cost of labour, as everything was done *from the inside* to prevent the work being noticed by the enemy.

Where the inside was lower than the outside, shafts were sunk, and chambers were made in the wall at the level of the floor inside; and where the inside was lower than the outside, chambers were made in the wall, and material for tamping was heaped up.

Agreeably to the order of the Commander of the Forces, these mines were not loaded.

The charges of the interior and exterior walls being brought to several foci, the former by hose, and the latter by powder trains, the whole were fired at 4 p.m., 28th February.

The first effect of the explosion was very incomplete; on the exterior about half the charges had brought down the walls, one-fourth had blown out the tamping, more or less shaking the wall, but not bringing it down, and the remainder had not been fired, the hose having been cut previous to ignition; at the partition walls, the charges had proved insufficient, a great part being left standing, though greatly shaken.

In the cellars the greater part of charges had gone off, producing the desired effects of blowing in the arches of the vaults and bringing down the partition walls.

There can be little doubt that the charges outside in sand-bags got injured by the damp, having lain in the ground 55 hours previous to firing, exposed to snow and thaw; it is probable also that the powder train did not burn equally, so that some charges going off before others, cut the connections.

Inside it appeared evident that charges of 15 lbs. were not sufficient to bring down the 3-feet partition walls, and tamping only 5 feet thick does not appear to have been enough, the soil being light and not easily rammed.

On the 29th a portion of the charges that had not gone off were fired, and eight more charges of 30 lbs. were placed at the centre partition wall of the west wing, which, together with the whole of the remaining centre of the building, was destroyed, bringing down part of the roof.

On March 1st, the bits of exterior wall left standing were demolished by eight charges of 40 lbs., placed as before, and the partition wall of the east wing by eight of 30 lbs.; the result was to bring down every part of the building except the north and gable walls, as ordered.

The remainder of the roof came down.

Western Range.

The demolition of these buildings was principally effected by blasting the window piers. (Figs. 2, 5, and 4, plate 4).

Holes varying from 4 feet to 4 feet 6 inches deep, according to the character of the stone, were bored on each side of the window piers, (Fig. 4, Plate 4) the charges were from 2 to 3 pounds, or as much as would fill two feet of each hole; the masonry being of a loose and inferior description, it was sometimes necessary to use 4 lbs.

In the north building, × holes were made in the angles of the partition walls, and holes were bored at the side doors of the passages. (Fig. 5, Plate 4).

In the angle where the × holes were made charges of 25 lbs. were used; but for the other angles charges of 50 lbs. were used. (Fig. 2, Plate 4.)

In the centres of all the partition walls were placed charges of 30 lbs., lodged in shafts, and tamped to a length of about twice L.L.R. (Fig. 5, Plate 4).

For the demolition of the arched vaults in the northern portion of the south building, seven 25 lb. charges were placed in front, one of 50 lbs. at the angle, and three of 30lbs. at the gable. (Figs. 2, 3, and 6, Plate 4).

The seven charges in the east face were all placed in shafts 3′ 6″ deep, and chambers 2′ 6″ long were made in the wall (Fig. 1, Plate 4). For the charges in the gables and partition walls the chambers were one foot long.

Three charges of 200 lbs. each were also placed in the centres of the vaults, and the windows were tamped. (Fig. 2, Plate 4).

The mines of the partition and gable walls were brought to foci by hose ; and the six feet lengths of fuze from the blasts were led in pairs across the window openings, the fuzes at their junctions being let into a powder hose or train supported on boards running along the building at a level of about three feet above the window sills.

For each partition wall of the south building there were six charges ; one of 50 lbs., one of 30 lbs., and four of 25 lbs. each. (Fig. 2, Plate 4).

For partition walls of the north building there were one of 30 lbs., two of 25 lbs., two blasts of 2½ lbs. each, and in one × hole 5 lbs. (Fig. 5, Plate 4).

On the 28th February, at 4 p.m., the whole were fired simultaneously with those in the north range.

The effect was not altogether successful, a great part having missed fire, owing in some circumstances to the badness of the fuze, and in others to the boards, on which the powder train was laid, being upset ; fresh arrangements were made, and at about 5 p.m. the unexploded charges were again ignited, and the result was in great measure successful ; the vaults were completely destroyed.

The late Major Ranken himself fired the focus of the four charges in the gable of the south building, and it was in lighting these that the lamentable accident occurred which caused his death.

The focus was to be fired by a three-feet length of fuze ; in the act of lighting this it appears that some loose powder ignited and fired the hose, thus exploding the four charges immediately.

The effect of this last explosion was only too successful, for it brought down the whole of the gable wall and angle of the building, together with the remaining portion of the roof before Major Ranken could escape, and his body was not found until 8 o'clock the next morning, crushed and buried beneath a heap of rubbish.

On the 1st of March the whole of the charges that had not been ignited, together with a few extra charges in some remaining fragments, were fired with complete success, the whole of the east face, with half of the gable and partition walls, being demolished.

CENTRAL BUILDINGS.

For the demolition of the Clock Tower, four charges of 90 lbs. each, (Figs. 10 and 11, Plate 4) were placed at the angles, in shafts 5′ 9″ deep, with chambers cut two feet long in the wall.

Two charges of 45 lbs. were similarly placed in the passage underneath the tower.

For the demolition of the building adjoining, a trench was made on each side of the exterior wall 4′ 6″ deep, the charges being at intervals of 11 and 12 feet, placed at the window piers in the interior, and brought to foci by powder trains ; (Figs. 11 and 12, Plate 4.) Charges of 15 lbs. were lodged along the walls, and others of 25 lbs. at the angles.

For the demolition of the vaults, charges were placed along the exterior walls about 10 and 12 feet apart, in shafts 8 and 9 feet deep. (Figs. 7, 8, and 9, Plate 4.)

The thickness of the wall being 3′ 6″ the charges were 30 lbs each.

The mines of the central buildings were also fired at 4 p.m. on the 28th ; but nearly all failed.

The damage done to the trains and hoses having been repaired, they were again lighted, and the effect was in great part successful.

The clock tower and adjacent building were entirely demolished ; the two exterior vaults (Nos. 1 and 2, Fig. 8, Plate 4,) were also completely demolished, and the exterior side of No. 3 was blown in. The charges at the sides of Nos. 2 and 4 missed, the hose connections being cut.

On the 1st March the remaining six vaults were demolished.

In the morning, charges of 600 lbs. were placed in each of the vaults Nos. 5 and 6, viz., 300 lbs. against the centre of each pier. (Figs. 8 and 9, Plate 4.)

In order to obtain a greater lateral effect, and to ensure the destruction of the vaults Nos. 3, 4, 7, and 8, the loading of the centre vaults was increased by blowing down the superincumbent part of the building before the explosion of the charges in the vaults.

The windows of the vaults Nos. 5 and 6 were securely tamped with stones and earth, and the doors were built up and strongly strutted ; the charges were brought to a focus in the middle of the passage.

For blowing down the partition above, eight charges were used, viz. four of 45 lbs. and four of 15 lbs., the latter being nearest to the crown of the arch.

The whole were then fired together, the upper charges exploding first, and then the lower ones.

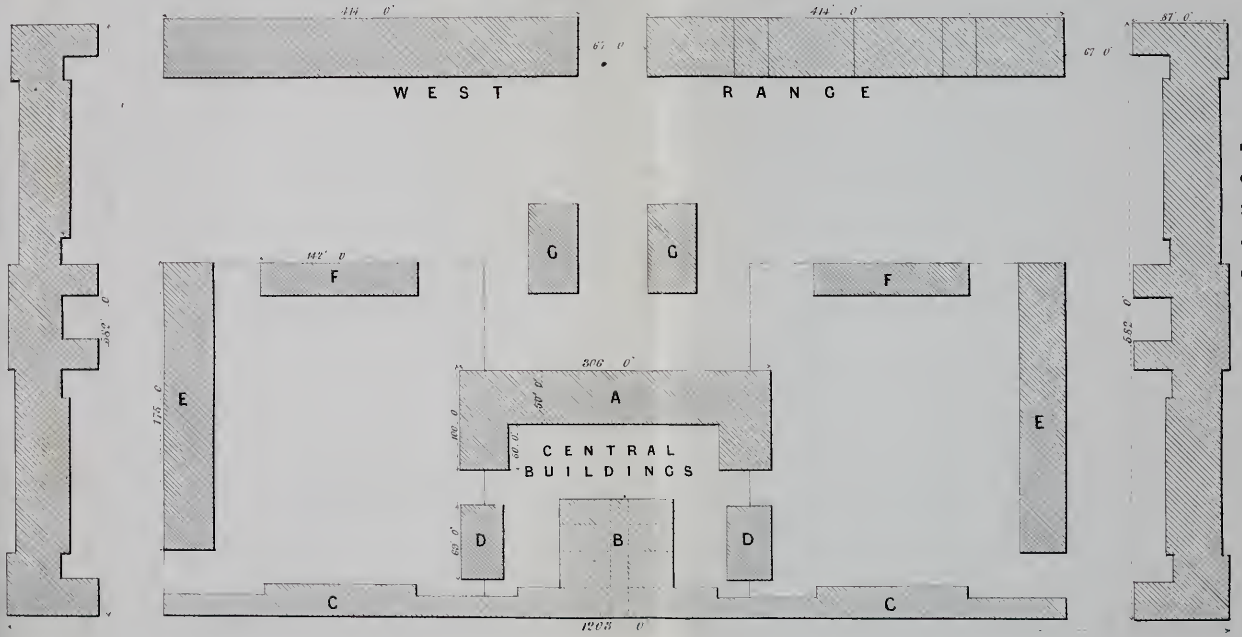
From some unexplained cause, the charges of No. 5 vault went off before the charges of No. 6, so that the effect of the latter was not so complete as intended. The vaults Nos. 3, 4, and 7 were entirely demolished, but No. 8, though the intermediate pier was much shaken, remained standing ; the exterior walls of Nos. 5 and 6 were blown out, and a great part of the upper building was destroyed.

EDWARD T. LLOYD, Lieut. Colonel,
Commanding Royal Engineer.

4th April, 1856.

[Note.—The following officers of Royal Engineers were employed on the demolition of these buildings, under the orders of Lieut. Colonel Lloyd, Commanding Royal Engineer, assisted by Colonel Gordon, R.E., viz. the late Major Ranken, until his death, and Lieut. G. Graham during the whole time.—Ed.]

PLAN
OF THE
WHITE BUILDINGS
AT
SEBASTOPOL.



REFERENCES.

A. *Clock Tower Building (one story with timber of roof complete.*

C. *Building of one story with vaults & roof timbers complete.*

B. *Building containing Kitchen and Vaults.*

D. E. F. G. *Small out houses with no roofs*

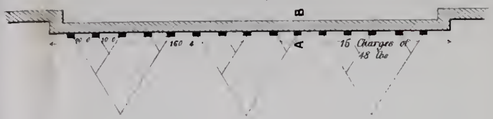
G. Graham, Lt. R. E.
30th March
1856.

E. T. Lloyd, Lt. Col.
Comg. Rl. Engrs.
4th April, 1856.

SCALE OF FEET.

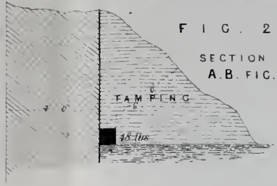
C Moody, Lith. 257, Holborn, London.

F I G. 1.



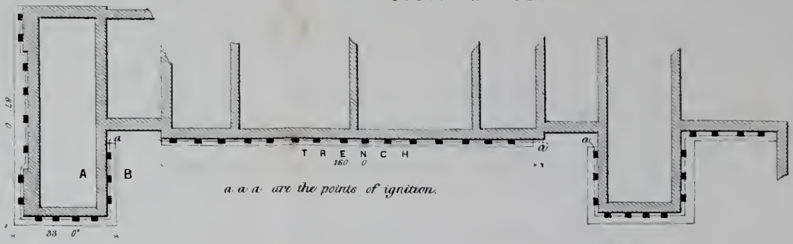
F I G. 2.

SECTION ON A.B. FIG. 1.



F I G. 5.

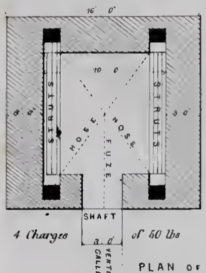
PLAN OF PART OF SOUTH RANCE.



a a a are the points of ignition.

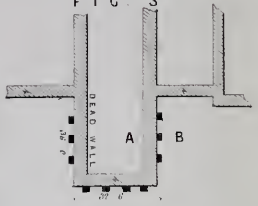
F I G. 11.

PLAN OF VENTILATOR

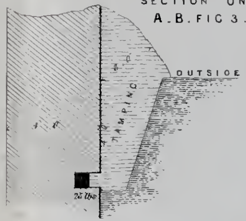


4 Charges of 50 lbs

F I G. 3

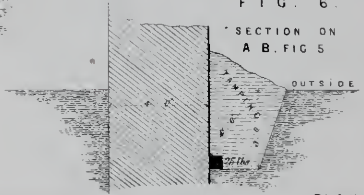


SECTION ON A.B. FIG 3.

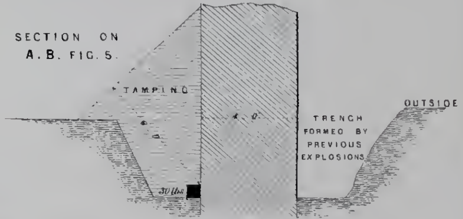


F I G. 6.

SECTION ON A B. FIG 5

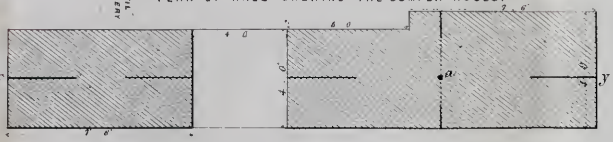


SECTION ON A.B. FIG. 5.



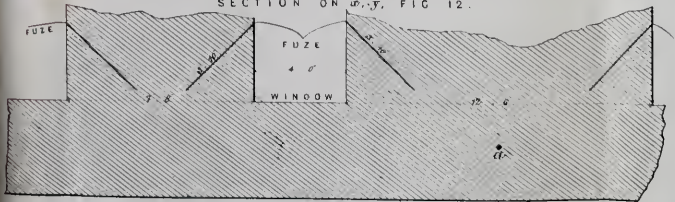
F I G. 12

PLAN OF WALL SHEWING THE JUMPER HOLES.



F I G. 13.

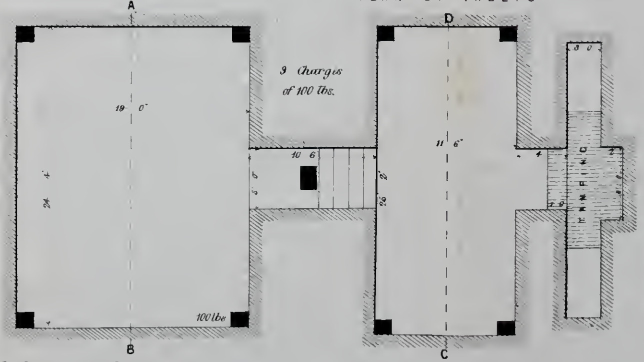
SECTION ON x.y. FIG 12.



The jumper holes intersect at a.

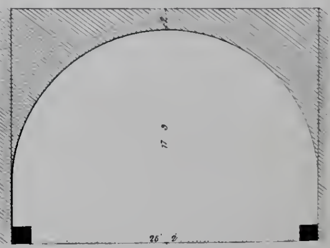
F I G. 8.

PLAN OF VAULTS



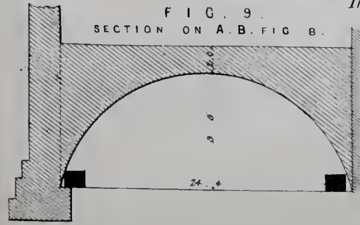
F I G. 10.

SECTION ON C. D. FIG. 8.

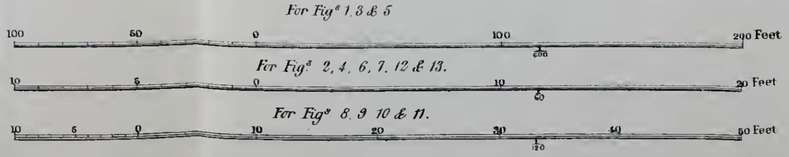


F I G. 9.

SECTION ON A. B. FIG 8.



S C A L E S



For Figs 1, 3 & 5

For Figs 2, 4, 6, 7, 12 & 13.

For Figs 8, 9 10 & 11.

The oblique shading shews Masonry
The horizontal shading shews earth.

Edwd T. Lloyd Lt Col.
Comg Rl Engr
4th April, 1856.

G. Graham Lt R. E. March 30th 1856.

C Moody Lith, 257, Holborn, London

FIG. 1.

SECTION ON N.O.

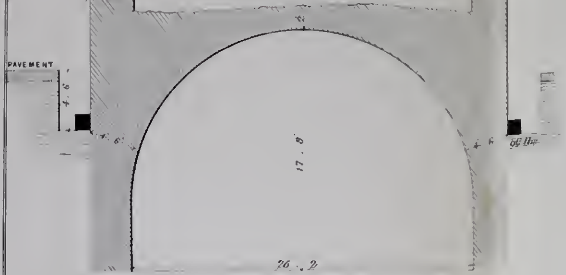


FIG. 2.

SECTION ON L.M.

(see Plan. Fig 3. Pl. 2.)

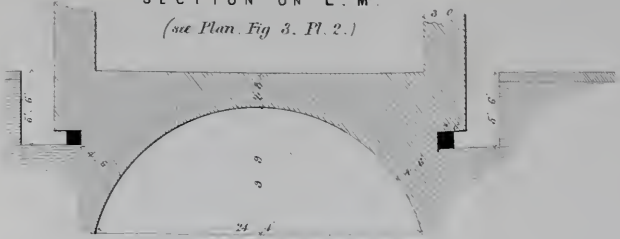


FIG. 3.

SECTION ON I.K.

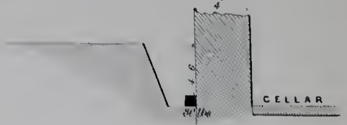


FIG. 4.

SECTION ON C.D.

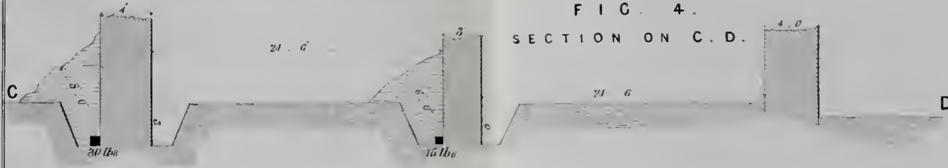
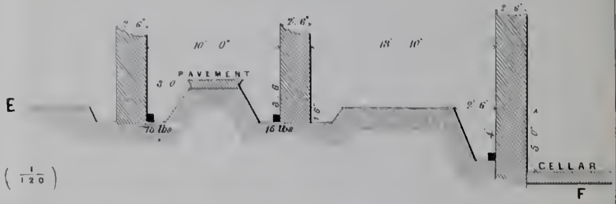


FIG. 5.

SECTION ON E.F.



SCALE FOR FIGS 1 TO 5 ($\frac{1}{120}$)

N.B. *The oblique shading represents Masonry & the horizontal shading earth.*

FIG. 6.

SECTION ON A.B (FIG. 6.)

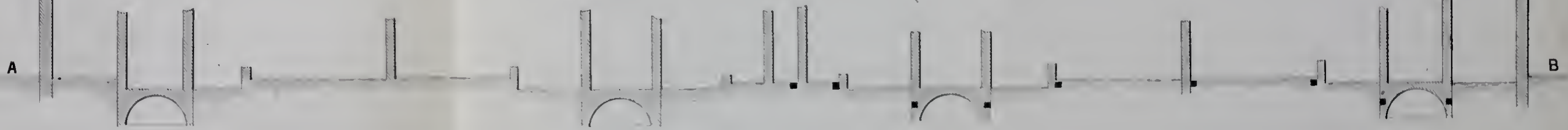
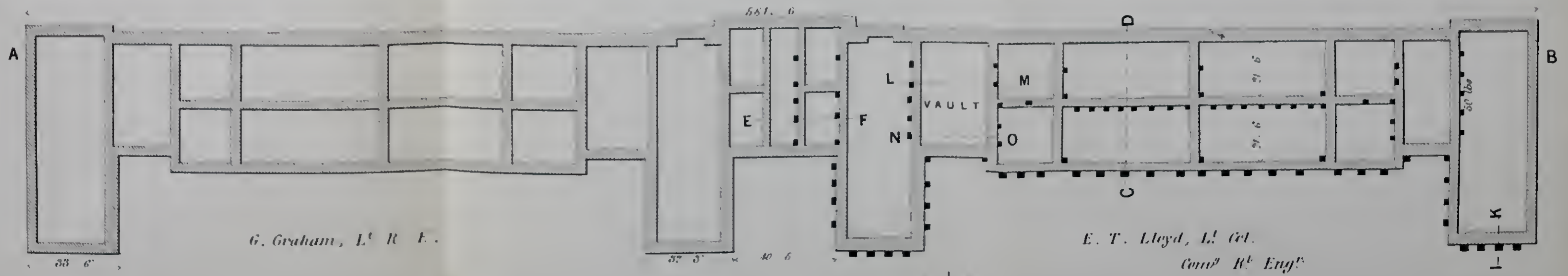


FIG. 7.

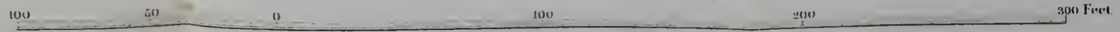
PLAN OF THE NORTH RANGE.



G. Graham, Lt R. E.

E. T. Lloyd, Lt Col.
Comg Rl Engr

SCALE FOR FIGS 6 & 7. ($\frac{1}{600}$)

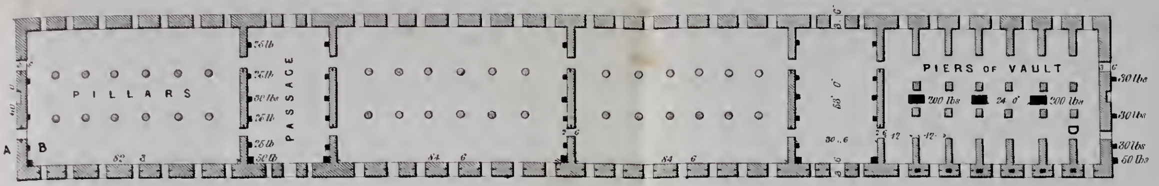


C. Moody, Lith, 257, Holborn, London.

PLAN OF WESTERN RANG

FIG. 2.

SOUTH BUILDING.



N.B. The dark lines in the wall shew the blasts.

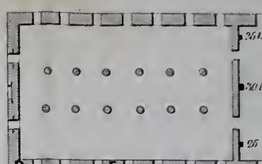


FIG. 7.

SECTION ON E. F. FIG. 8.

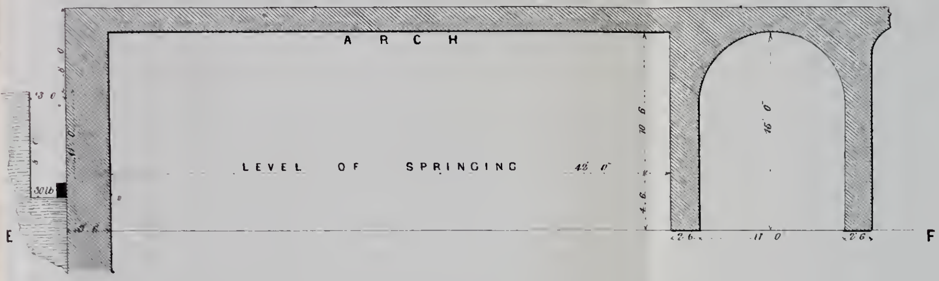
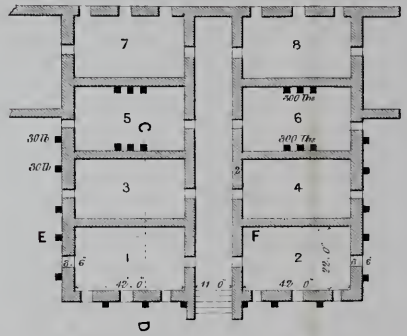


FIG. 8.

PLAN OF VAULTS.



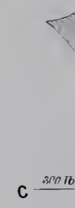


FIG. 1.

SECTION ON A. B, FIG. 2.

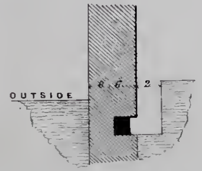


FIG. 3.

PLAN OF PIER OF VAULT, FIG. 2.

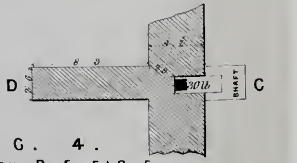
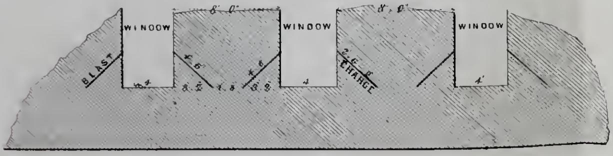


FIG. 4.

SECTION ON D. E. FIG. 5.



SCALE OF FEET

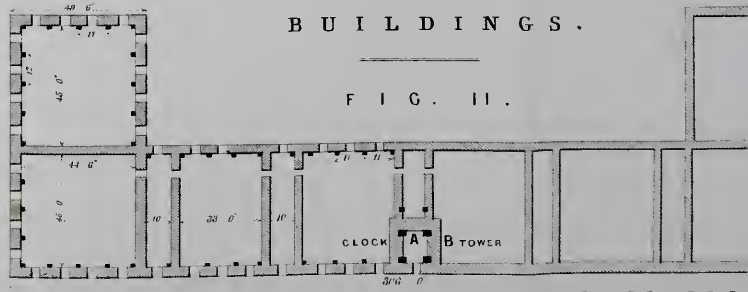
For Figs 1, 3, 4, 6 7, 9, 10, & 12.

G. Graham, Lt R. E.

CENTRAL

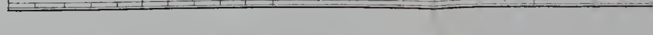
BUILDINGS.

FIG. 11.



SCALE OF FEE

For Figs 2, 5, 8 & 11.



N OF WESTERN RANGE.

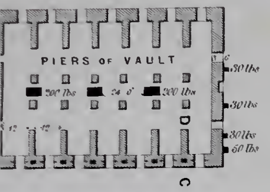


FIG. 5.

NORTH BUILDING.

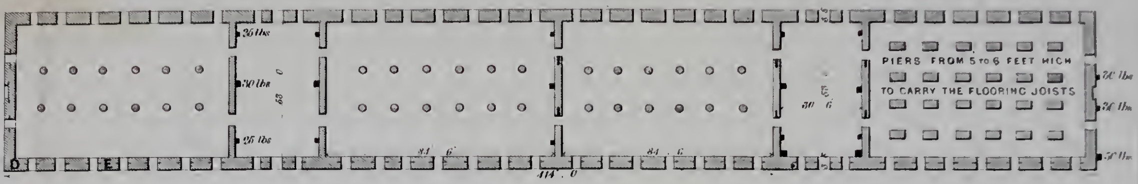


FIG. 8.

PLAN OF VAULTS.

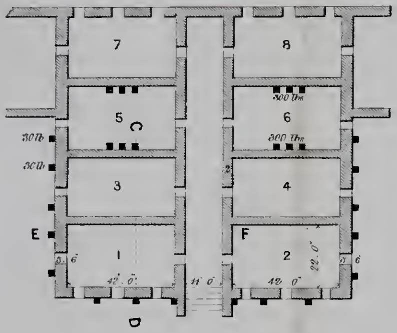
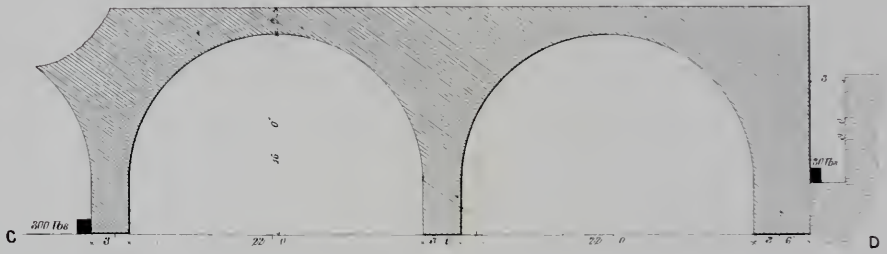


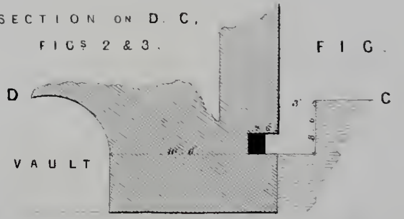
FIG. 9.

SECTION ON C. D. FIG. 8.



SECTION ON D. C,
FIGS 2 & 3.

FIG. 6.



CENTRAL BUILDINGS.

FIG. 11.

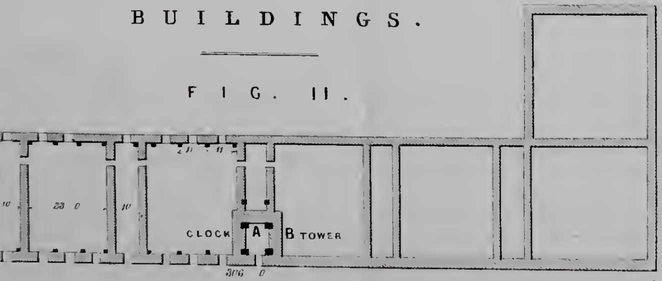


FIG. 10.

SECTION ON A.B,
FIG. 11.

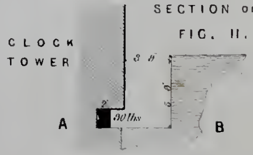
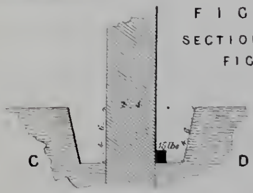
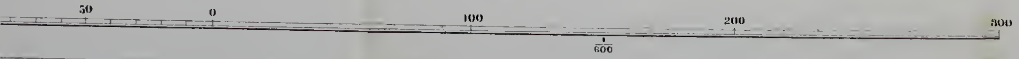


FIG. 12.

SECTION ON C. D.
FIG. 11.



SCALE OF FEET
For Figs 2, 5, 8 & 11.



The oblique shading shews masonry.
The horizontal shading shews earth

C Mealy [illegible]

PAPER IV.

Report on the French Troops and Materiel sent to the Crimea in 1854 and 1855.

Written by MARSHAL VAILLANT, Minister of the War Department.

Letter from the Emperor of the French to Marshal Vaillant.

A. S. Exc. le maréchal Vaillant, ministre de la guerre.

Compiègne, le 22 *octobre* 1856.

Mon cher maréchal,

Les services les plus utiles ne sont pas toujours les plus éclatants. Le ministre habile et infatigable qui, jour et nuit, s'occupe dans son cabinet d'organiser 600,000 hommes et d'assurer à une armée de 200,000 tout ce qui lui donnera le moyen de vivre, de combattre, de vaincre sur une terre sans ressources à 800 lieues de la France ; ce ministre, dis-je, a un mérite au moins égal à celui du général qui triomphe sur le champ de bataille. Aussi là patrie doit elle confondre dans sa reconnaissance celui qui prépare la victoire par les éléments réunis à temps, et celui qui la remporte par des mesures bien prises sur les lieux mêmes.

C'est pourquoi, mon cher maréchal, en ordonnant l'insertion au *Moniteur* du rapport remarquable que vous m'avez adressé, j'ai voulu rendre le public juge de services dont moi seul jusqu'ici je connaissais toute l'importance.

Recevez, mon cher maréchal, l'assurance de ma sincère amitié.

NAPOLÉON.

RAPPORT A L'EMPEREUR.

Paris, le 8 *septembre* 1856.

Sire,

La guerre qui vient de se terminer d'une manière si glorieuse pour les armes de Votre Majesté et de ses augustes alliés s'est accomplie dans des conditions tout exceptionnelles. Pour porter en Orient et y maintenir au complet des armées qui, sous les drapeaux de la France, de l'Angleterre et de la Sardaigne, ont compté plus de 200,000 combattants, pour les approvisionner de tout ce qui leur était nécessaire, il a fallu créer ou développer d'immenses moyens.

J'ai pensé que Votre Majesté lirait avec intérêt un rapport exposant l'ensemble de ces moyens en ce qui concerne l'armée française, dont l'effectif s'est élevé à 150,000 hommes dans le cours de l'année 1855, et que, peut-être, Elle daignerait reconnaître que l'administration de la guerre, obéissant à la puissante impulsion de l'Empereur, a fait preuve de zèle dans l'accomplissement d'une tâche laborieuse.

Ce rapport comprend trois parties distinctes:

La première traite du *Personnel même de l'armée ;* elle donne le chiffre des troupes embarquées pour l'Orient; le chiffre de celles qui sont revenues, soit en France, soit en Algérie; elle indique les mesures de précaution prises au départ, au retour, etc.

La deuxième partie, sous le titre de *Matériel,* montre quels ont été les moyens de l'artillerie aux différentes époques de la guerre ; l'importance et l'étendue des envois de munitions de toute espèce dirigés sur la Crimée; les envois faits par le génie ; les approvisionnements que l'administration militaire proprement dite a expédiés pour la subsistance des troupes, pour le chauffage, pour les fourrages, l'habillement, le campement, le harnachement; les ressources et approvisionnements concernant le service hospitalier, tant pour les hôpitaux mobiles que pour les ambulances légères. Cette partie indique aussi quelle a été l'organisation du service religieux dans nos hôpitaux et à l'armée même. Elle présente le tableau des moyens mis à la disposition des équipages militaires, et traite de quelques services que je n'ose appeler accessoires, bien qu'ils ne figurent qu'*en seconde ligne,* à savoir: de la trésorerie, des postes, de l'imprimerie et de la télégraphie, qui apparait pour la première fois comme service régulièrement attaché à une armée.

La troisième partie présente l'ensemble des *moyens maritimes* employés pour transporter des ports de France et d'Algérie, à Gallipoli, à Constantinople, à Varna, à Eupatoria, et, enfin, au port providentiel de Kamiesch, l'armée d'Orient et ses immenses approvisionnements, ainsi que pour en assurer le retour. Quelque grand et empressé qu'ait été le concours de la marine impériale, il a fallu cependant noliser un nombre considérable de navires de commerce, et l'administration de la guerre a transporté, par ses propres ressources, une notable partie du personnel de l'armée, ainsi que la presque totalité des chevaux et du matériel.

Les chiffres portés aux tableaux qui suivent n'ont pas besoin de commentaire ; ils témoignent suffisamment de la grandeur de l'entréprise et des efforts qui ont été faits en vue de réaliser les projets de Votre Majesté, et de pourvoir, conformément à ses ordres, non pas seulement aux besoins, mais encore au bien-être de ses soldats de l'armée d'Orient.

PREMIÈRE PARTIE.—Personnel.

MOUVEMENT DES TROUPES.

DÉPART.

	HOMMES.	CHEVAUX.
Nombre des hommes et des chevaux embarqués en France..	257,324	35,777
Nombre des hommes et des chevaux embarqués en Algérie..	47,983	5,967
Nombre des hommes et des chevaux embarqués en Corse..	1,998	
Nombre des hommes et des chevaux embarqués en Italie (division d'occupation)	1,963	230
Total des envois de troupes	309,268	41,974

Pertes éprouvées par l'Armée.

Le chiffre des décès, à la date du 30 Mars 1856, s'élevait à		62,492
Depuis cette époque jusqu'à la fin de l'évacuation (période du typhus et du choléra), il est mort 4,564 hommes, ci		4,564
Total des décès constatés		67,056
Les hommes disparus et les prisonniers de guerre formaient, sur les états de situation de l'armée, une seule catégorie qui, pour la durée du siége, donne un chiffre de	2,573	
Les échanges de prisonniers sont aujourd'hui à peu près terminés, et la Russie à rendu à la France 792 militaires de tous grades, ci	792	
Le nombre des hommes disparus qu'il y a lieu de porter au compte des pertes de l'armée est donc de	1,781	
Militaires qui ont péri dans le naufrage de *la Sémillante*		392
Total des pertes de l'armée		69,229

RETOUR.

				HOMMES.	
Militaires rentrés isolément en convalescence ou en congé.					65,069
Corps rappelés de l'armée avant la signature de la paix	Régiment de tirailleurs algériens			1,822	20,390
	Régiment de gendarmerie de la garde			1,166	
	Division de la garde impériale.			12,000	
	20e, 39e, 50e, 97e régiments de ligne et 3e bataillon de chasseurs à pied			5,402	
L'effectif de l'armée d'Orient au 30 Mars 1856, était de 146,240 hommes, ci				146,240	
Savoir :—		HOMMES.			
En Crimée		120,476	146,240 hommes.		
En Turquie :					
Sous les armes.....	15,316	25,764			
Aux hôpitaux......	10,448				
Le chiffre des décès survenus pendant l'évacuation est, ainsi qu'on la vu plus haut, de				4,564	
Il est donc revenu d'Orient depuis la signature de la paix..				141,676	141,676
Total des hommes revenus de l'armée...........					227,135

RÉSUMÉ.

	HOMMES.
On a transporté en Orient	309,268
Les pertes de l'armée sont de..	69,229
	240,039
Il est revenu d'Orient en France et en Algérie	227,135
Différence	12,904

Dans ce dernier chiffre sont compris, d'une part, tous les individus qui, sans être liés au drapeau, sont partis avec l'armée ou à sa suite, et, d'autre part, les officiers et soldats qui ont été embarqués plusieurs fois pour l'Orient. Ce sont des militaires rentrés en France en convalescence ou en congé et qui sont retournés à l'armée après leur rétablissement ou l'expiration de leur congé: ils figurent au moins deux fois dans le chiffre total des hommes embarqués.

La majeure partie des chevaux a été transportée de Crimée en Turquie et cédée au gouvernement ottoman. Il en a été ramené environ 9,000 en France et en Algérie.

OBSERVATIONS.

Pour suffire tant aux besoins de la guerre en Orient qu'aux réunions de troupes à opérer sur divers points de l'intérieur de l'empire (Paris, Lyon, Metz, Lunéville, camps de Boulogne, de Saint-Omer et du Midi), ainsi que pour maintenir l'effectif de l'armée d'Afrique, on a créé plusieurs corps et réalisé des accroissements de cadres.

9 Mars 1854. Création, pour l'armée d'Orient, d'un régiment de tirailleurs algériens.

20 Avril 1854. Création d'un 6e escadron dans 53 régiments de cavalerie.

1er Mai 1854. Rétablissement de la garde impériale. Cette garde est ainsi composée :
1 régiment de gendarmerie à 2 bataillons, formé avec les 2 bataillons de gendarmerie d'élite.
2 régiments de grenadiers à 3 bataillons (création nouvelle).
2 régiments de voltigeurs à 3 bataillons (création nouvelle).
1 bataillon de chasseurs à pied à 10 compagnies (création nouvelle).
1 régiment de cuirassiers à 6 escadrons (création nouvelle).
1 régiment de guides à 6 escadrons, formé avec le régiment des guides déjà existant.
1 régiment d'artillerie à cheval de 5 batteries et un cadre de dépôt (création nouvelle).
1 compagnie du génie (création nouvelle).

26 Mai 1854. Augmentation du cadre du personnel de l'habillement et du campement.

11 Juin 1854. Augmentation du cadre du personnel des officiers d'administration des bureaux de l'intendance militaire.

24 Juin 1854. Création, pour le service de l'armée d'Orient, d'un corps de cavalerie légère sous le nom de *spahis d'Orient.*

21 Juillet 1854. Augmentation du cadre des médecins et pharmaciens. (Par décret du 4 Août 1855, le cadre des médecins militaires est augmenté de 460 sous-aides).

12 Août 1854. Création d'un escadron de gendarmerie de la garde (formé avec les brigades affectées au service de surveillance des forêts de la Couronne et des routes fréquentées par l'Empereur).

14 Août 1854. Augmentation du cadre du personnel des subsistances militaires. Ce cadre est augmenté de nouveau par décret du 30 Juin 1855).

21 Sept. 1854. Augmentation du cadre des officiers d'administration des hôpitaux militaires.

15 Nov. 1854. Reconstitution des 6es compagnies des 3es bataillons dans les 100 régiments d'infanterie de ligne.

23 Déc. 1854. Création d'un régiment de zouaves de la garde impériale à 2 bataillons.

9 Janv. 1855. Création d'un second bataillon de tirailleurs indigènes dans chacune des trois provinces de l'Algérie.

17 Janv. 1855. Création d'une 2e légion étrangère, composée de deux régiments à deux bataillons et d'un bataillon de tirailleurs à dix compagnies.

17 Fév. 1855. Création de la garde impériale de :
Un 3e bataillon dans le régiment de gendarmerie.
Un 4e bataillon dans chacun des régiments de grenadiers et de voltigeurs.
Une 6e batterie dans le régiment d'artillerie à cheval.
1 deuxième compagnie du génie.
1 escadron du train des équipages.

17 Fév. 1855. Création d'un régiment d'artillerie à pied dans la garde impériale. (6 batteries à pied, 6 batteries de parc, 1 cadre de dépôt.)

7 Mars 1855. Augmentation de l'état-major général et du corps impérial d'état-major.

16 Mars 1855. Augmentation du corps de l'intendance militaire.

24 Mars 1855. Création d'un 4e bataillon dans les 100 régiments d'infanterie. (Cette mesure a été appliquée aux 2 régiments de la 1re légion étrangère.)

2 Avril 1855. Création de 2 régiments d'infanterie à 4 bataillons, qui prennent les Nos 101 et 102.

27 Juin 1855. Création d'un 7e et d'un 8e escadron dans chacun des 4 régiments de chasseurs d'Afrique.

14 Août 1855. Création de 2 bataillons de chasseurs à pied, qui prennent les Nos 21 et 22.

7 Nov. 1855. Licenciement du régiment de tirailleurs algériens, des 6 bataillons provinciaux de tirailleurs indigènes, et création de 3 régiments de tirailleurs algériens à 3 bataillons (1 régiment par province).

20 Déc. 1855. Réorganisation de la garde impériale et création des corps ci-après désignés :

Infanterie.
- 3e régiment de grenadiers à 4 bataillons.
- 2e régiment de voltigeurs à 4 bataillons.
- 4e régiment de voltigeurs à 4 bataillons.

Cavalerie.
- 2e régiment de cuirassiers à 6 escadrons.
- Régiment de dragons à 6 escadrons.
- Régiment de lanciers à 6 escadrons.
- Régiment de chasseurs à 6 escadrons.

En même temps les mesures suivantes étaient adoptées pour le recrutement de l'armée :

5 Janvier, 22 Janvier et 22 Févr. 1854. Décrets qui appellent à l'activité les jeunes gens encore disponibles sur les contingens des classes de 1852, 1851, 1850 et 1849.

10 Avril 1854. Loi qui élève de 80 à 140,000 hommes le contingent à appeler en 1854 sur la classe de 1853.

1er Mai 1854. Décret qui appelle à l'activité 80,000 hommes sur le contingent de la classe de 1853.

14 Sept. 1854. Décret qui appelle à l'activité les 60,000 hommes encore disponibles sur le contingent de 1853.

9 Nov. 1854. Décision impériale qui maintient sous les drapeaux les hommes de la classe de 1847.

24 Janv. 1855. Loi qui fixe à 140,000 hommes le contingent à appeler en 1855 sur la classe de 1854.

5 Mars 1855. Décret qui appelle à l'activité les 140,000 hommes de la classe de 1854. (Ils sont mis en route du 25 au 30 Mars.)

11 Juil. 1855. Loi qui maintient à 140,000 hommes le contingent à appeler en 1856 sur la classe de 1855.

19 Nov. 1855. Décision impériale qui maintient sous les drapeaux les hommes de la classe de 1848.

C'est dans la 9e division militaire, à Toulon et à Marseille, que se sont effectués presque tous les envois de troupes et de matériel. Le général de Rostolan, commandant la division, était chargé de la direction des opérations. Il s'est acquitté de cette tâche avec un zèle et une habileté auxquels on ne saurait donner trop d'éloges.

Le télégraphe transmettait constamment de Paris à Marseille les ordres de l'Empereur et les instructions du ministre de la guerre, dont l'exécution, quant aux transports, était accélérée par les chemins de fer et les bateaux à vapeur. Grâce à ces moyens, grâce surtout à un dévouement de tous les instants de la part des fonctionnaires militaires, l'armée française, bien qu'à 800 lieues de la mère patrie, a constamment reçu ses renforts en temps opportun; et n'a jamais attendu ni ses vivres ni ses vêtemens.

Les troupes dirigées sur l'armée de tous les points de l'Empire, soit par étapes, soit par les chemins de fer, n'arrivaient à Marseille et à Toulon qu'au fur et à mesure de la réunion des moyens de transport maritime. Jusque-là, elles étaient échelonnées dans les 8e et 9e divisions militaires, et, autant que possible, sur les lignes de chemins de fer qui les amenaient au port d'embarquement pour le moment précis du départ.

Une commission, présidée par un officier général, et composée d'officiers de toutes armes, veillait à ce que l'installation des troupes à bord fût aussi bonne que possible, et fixait le nombre des hommes et des chevaux à placer sur chaque navire, de manière à mettre la santé des passagers à l'abri des dangers qu'amène toujours l'encombrement. Tout en respectant à cet égard les limites indiquées par l'expérience, on put cependant combiner les départs de telle sorte que les détachements d'un même corps ne fussent pas fractionnés sur des bâtiments différents, avantage précieux pour la discipline, puisqu'on laissait ainsi les hommes de troupe sous les ordres de leurs chefs directs.

Les corps ou détachements de corps recevaient avant le départ une instruction relative aux mesures hygiéniques à observer pendant la traversée et aux dispositions à prendre pour assurer leur première installation en Orient.

Les navires du commerce étaient tenus d'avoir, comme ceux de l'Etat, des médecins et des médicaments. L'intendant militaire de la 9e division a souvent placé à bord de ces bâtiments des médecins militaires et des médecins civils requis.

Dès le commencement de l'hiver de 1854, les militaires convalescents ou envoyés en congé d'Orient en France arrivèrent en assez grand nombre à Marseille ; Ils furent réunis dans un dépôt dit de *débarquement*, où ils recevaient, pendant quelques jours, les soins que réclamait leur état de santé. Ils étaient dirigés ensuite, soit sur le dépôt de leur corps, soit sur la résidence où ils devaient jouir de leur congé.

En prévision des maladies que les fatigues de la guerre ne pouvaient manquer de développer dans une armée aussi nombreuse, les ressources hospitalières des divisions militaires riveraines de la Méditerranée avaient été augmentées dans une notable proportion.* Les malades évacués sur ces hôpitaux provisoires ont pu y être traités avec tous les soins convenables, malgré les difficultés occasionnées dans le service médical de nos villes du midi par les deux épidémies cholériques de 1854 et 1855. A mesure que les malades étaient reconnus en état de supporter un nouveau transport, ils étaient dirigés sur les hôpitaux militaires de l'intérieur.

Au moment où la marche des négociations rendit probable la prochaine rentrée des troupes en France, le typhus sévissait en Crimée et à Constantinople. L'Empereur, préoccupé de cette situation, prescrivit les dispositions à prendre pour soustraire le pays à l'invasion de cette nouvelle épidémie. Par ses ordres, le ministre de la guerre et le ministre de l'agriculture, du commerce et des travaux publics, sur l'avis du conseil de santé des armées et du comité d'hygiène, adoptèrent un ensemble de mesures qui fûrent immédiatement mises à exécution.

Indépendamment des précautions prescrites à l'armée qui était encore en Crimée, telles que l'isolement complet des détachements pendant quelques jours avant leur embarquement, il fut arrêté que les troupes seraient soumises à une quarantaine d'observation sur un point isolé du littoral.

* Un hôpital temporaire avait été créé à Avignon ; on avait transformé en hôpitaux la caserne de la Corderie, à Marseille, celle du Jeu de Paume, à Toulon, la Citadelle de Montpellier, et enfin le Château d'O, propriété de Monseigneur l'Evêque de Montpellier, que ce prélat avait généreusement offerte. De plus, l'hôpital militaire de Cette et les hangars du lazaret du Frioul, à Marseille, avaient été disposés pour recevoir ensemble 1,000 lits (en tout 3,000 lits.)

A cet effet, trois grands campements furent établis, savoir :

A l'île de Porquerolles, pour 12,000 hommes ;

A l'île Sainte-Marguerite, pour 6,000 hommes ;

Et sur la plage de Calvaire, près de Saint-Tropez, pour 12,000 hommes et un assez nd nombre de chevaux. Ce dernier point était spécialement affecté aux troupes à eval, afin d'éviter. à l'expiration de la quarantaine, un rembarquement des chevaux, ération toujours difficile.

En peu de jours, des puits furent creusés, des abreuvoirs construits, le matériel de npement transporté sur les lieux ; et, au moment où les premières troupes rentraient France, après la signature de la paix, les trois camps d'observation pouvaient evoir à la fois 30,000 hommes et 2,000 chevaux.

Trois officiers supérieurs expérimentés avaient été investis, à leur retour d'Orient, commandement de ces camps.

En même temps, on construisit des baraquements susceptibles de recevoir dans les illeures conditions 500 malades à Sainte-Marguerite, autant à Porquerolles et 250 Calvaire.

M. Maillot, médecin inspecteur militaire, fut envoyé de Paris pour installer le sonnel médical ; et M. Mélier, inspecteur général de la santé publique, fut chargé le ministre de l'agriculture, du commerce et des travaux publics, de la direction à ner à l'observation des réglemens sanitaires. M. le docteur Blache, directeur du vice de la santé à Marseille, facilitait la tâche du commandement.

Des dispositions analogues étaient adoptées dans les ports de l'Algérie où devaient arquer les corps attachés d'une manière permanente à l'armée d'Afrique.

Les premiers arrivages (Avril 1856) se firent dans les conditions qui viennent d'être iquées, et toutes les troupes de la division de Failly séjournèrent quelques jours au np de Porquerolles, de même que les congédiés de la classe de 1849.

Mais bientôt la cessation de l'épidémie de Crimée et l'excellent état sanitaire des upes débarquées permirent de se montrer moins sévère pour l'admission en libre tique des navires chargés de troupes. Jusqu' à la fin de l'évacuation cependant, furent astreints à aller arraisonner à Porquerolles, où l'on s'assurait de l'état sani- es des troupes, qui étaient ensuite débarquées à Marseille. Aprés l'arrivée de la sion de Failly, deux navires seulement furent retenus : l'un, chargé de troupes à l, les debarqua à Porquerolles ; l'autre, chargé de troupes à cheval, les porta à alaire.

Bien que les embarquements en Crimée fussent successifs, les événements de mer aient nécessairement amener des arrivages simultanés ; et comme les troupes ne taient Marseille qu'en nombre limité, afin de ne pas encombrer les routes, que les ndations vinrent d'ailleurs rendre impraticables, on aurait été forcé, dans le cas de arrivages multiples, de recourir au logement chez l'habitant. Mais des craintes gérées sur l'état sanitaire des troupes revenant de Crimée avaient été conçues ; il it les dissiper et rassurer les populations. A cet effet, le général de Rostolan tablir en peu de jours. aux abords de Marseille, six camps susceptibles de loger 00 hommes et 2,000 chevaux. La sagesse de ces prévisions ne tarda pas à être ontrée, et, à plusieurs reprises, 10,000 hommes et 1,200 chevaux se sont trouvés à is dans ces camps. C'est ainsi que plus de 100,000 hommes et 5,000 chevaux dans l'espace de trois mois, traversé Marseille sans qu'un seul homme ni un seul al aient été logés chez l'habitant. Au surplus, l'état sanitaire des troupes réunies les camps a été constamment satisfaisant.

e rapatriement de l'armée s'est terminé par l'évacuation des hôpitaux de Constan- ple ; les frégates hôpitaux de la marine impériale ont fait les premiers transports nalades et les ont déposés aux îles Sainte-Marguerite et Porquerolles ; l'hôpital time de Saint-Mandrier a reçu les derniers.

Les camps et hôpitaux temporaires sont évacués depuis quelque temps déjà. Les malades restant à Saint-Mandrier quittent chaque jour cet hôpital qui sera trés-prochainement remis à l'entière disposition du ministre de la marine.

Un delai de six mois à compter du 27 Avril, date de l'échange des ratifications du traité de paix, avait été fixé pour l'évacuation complète des territoires occupés par les alliés. Cette opération a commencé le 11 Avril, et moins de trois mois aprés, le 5 Juillet, malgré tous les embarras et les retards causés par la maladie qui sévissait alors sur notre armée, le maréchal Pélissier qui avait voulu présider lui-même au rembarquement de tous ses soldats, quittait le dernier la Crimée. Constantinople voyait partir, le 18 Août, nos dernières troupes avec le général Pariset, commandant militaire.

DEUXIEME PARTIE.—Matériel.

MATÉRIEL DE L'ARTILLERIE.

PARC DE SIÉGE.

			Quantités.
Bouches à feu..	Canons	de 24	72
		de 16	44
		de 12 de campagne	20
	Canons-obusiers	de 12	24
		de 12 légers	12
	Obusiers	de 22 de place	20
		de 22 de siége	55
		de 16 de campagne	20
		de 12 de montagne	12
	Mortiers	de 32	102
		de 32 de côte	18
		de 27	118
		de 22	103
		de 15	24
		Total des bouches à feu	644

Matériel mis à la disposition du parc de siége par la Marine.

Bouches à feu avec affûts et approvisionnements	Canons	de 50	8
		de 30 No. 1	338
		de 30 No. 2	18
		de 30 rayés	6
	Canons-obusiers de 30		9
	Obusiers	de 80 No. 1	71
		de 80 No. 2	17
	De divers calibres mis hors de service dans le tir		138
		Total des bouches à feu	605
Bouches à feu turques de tous calibres, avec affûts			140
Affûts	de siége pour canons..	de 24	170
		de 16	64
	de place pour obusier de 22 en fonte		25
	de campagne	de 12	54
		légers de 12	36
	de montagne pour obusier de 12		16
	de mortier	de 32	129
		de 32 de côte	18
		de 27	147
		de 22	131
		de 15	31
		Total des affûts	811

Voitures diverses ..	Chariots porte-corps	141	779
	Triqueballes	18	
	Chariots de parcs	250	
	Chariots de siége	220	
	Caissons à munitions	80	
	Chariots de batterie	25	
	Forges de campagne	45	
	Total des voitures	779	

Projectiles	Boulets	de 24	195,600
		de 16	87,920
	Obus	de 22	166,000
		de 15	78,000
		de 12	41,000
	Bombes	de 32	154,350
		de 32 de côte	13,850
		de 27	202,000
		de 22	142,500
	Grenades à main		75,000
	Boîtes à balles	de 24	1,600
		de 16	1,500
	Total des projectiles		1,159,320

Poudres et munitions confectionées	Cartouches à boulet pour canon de 12	20,240
	Coups à obus et à balles pour obusier de 16	20,240
	Cartouches à obus et à balles pour cannon-obusier	10,000
	Cartouches à obus pour obusier de montagne	4,000
	Etoupilles fulminantes	2,019,000
	Poudre à canon en barils (kilogr.)	2,474,000

ARTILLERIE DE CAMPAGNE.

Bouches à feu	Canons-obusiers de 12	174
	Canons-obusiers de 12 légers	66
	Obusiers de montagne	6
	Total des bouches à feu	246

Affûts et voitures	Affûts légers de 12		320
	Affûts de montagne		7
	Caissons à munitions	de bouches à feu	480
		d'infanterie	196
	Chariots de batterie		80
	Forges de campagne		80
	Total des affûts et voitures		1,163

Munitions.	Coups pour	canon-obusier.	45,760
		obusier de montagne.	336
	Cartouches d'infanterie	à balle sphérique.	2,527,900
		à balle oblongue.	1,503,360

PARC DE CAMPAGNE.

Bouches à feu.	Canons obusiers de 12.	6
	Canons-obusiers de 12 légers.	42
	Obusiers de 12 de montagne.	11
	Total des bouches à feu.	41

Affûts et voitures	Affûts légers de 12.		173
	Affûts pour obusiers de montagne.		27
	Caissons à munitions.	pour canon-obusier de 12.	618
		pour cartouches d'infanterie.	340
	Chariots.	de parc.	61
		de batterie.	62
	Forges.	de campagne.	28
		de montagne.	16
	Total des affûts et voitures.		1,325

Munitions. (A)	Coups.	pour canon-obusier.	219,996
		pour obusier de montagne.	3,264
	Cartouches d'infanterie à balle.	sphérique.	61,606,868
		oblongue.	
		évidée pour la garde.	
		Nessler.	

(A) Ces munitions réunies à celles portées par les caissons qui étaient en ligne, donnent un approvisionnement de 1,107 coups par pièce de campagne et 600 coups par pièce de montagne. Quant aux munitions d'infanterie, l'approvisionnement était de 547 cartouches par homme, indépendamment de 60 cartouches emportées par les hommes au moment de l'embarquement.

En résumé, le matériel d'artillerie dont disposait l'armée d'Orient comprenait :

1,676	bouches à feu de tous calibres,
2,083	affûts,
2,740	voitures,
2,128,000	projectiles,
4,000,000	kilogrammes de poudre.

OBSERVATIONS.

Aussitôt que l'expédition de Crimée fut résolue, on fit embarquer et on expédia en Orient un équipage de siége d'une soixantaine de bouches à feu, qui avait été réuni à Toulon en prévision des éventualités de la guerre. Ce fut avec cet équipage que l'on se présenta devant Sébastopol.

L'énergie de la défense, la quantité considérable de bouches à feu que la place mettait en batterie, le défaut d'investissement qui donnait à ce siége un caractère particulier, en permettant à l'ennemi de se ravitailler continuellement, firent bientôt reconnaître l'insuffisance des moyens d'attaque dont on disposait, et l'on dut donner à l'équipage de siége un accroissement en dehors de toutes les premières prévisions.

Il fallut réunir successivement à Marseille et à Toulon, et envoyer en Crimée trois équipages supplémentaires : le premier, de 58 bouches à feu ; le second, de 46, et le troisième, de 150. Toutes ces bouches à feu étaient approvisionnées de 1,500 à 2,000 coups par pièce.

L'école de pyrotechnie, qui s'occupait depuis plusieurs mois, par ordre de l'Empereur, d'établir des fusées de guerre de gros calibre ayant des portées de 5 à 7,000 mètres, avait déjà obtenu des résultats très-remarquables. Il lui fut prescrit d'activer encore ses fabrications, et elle parvint à confectionner et à expédier au parc de siége 7 à 8,000 de ces fusées de guerre.

De son côté, le commandant en chef de l'armée tira de l'arsenal de Constantinople 140 bouches à feu, des projectiles, et surtout de la poudre en quantité considérable. Il demanda en même temps à la flotte, pour l'armement des batteries, des bouches à feu d'un puissant calibre; le nombre des pièces empruntées ainsi aux vaisseaux et mises à la disposition du parc de siége s'éleva bientôt au chiffre de 605, dont 238 étaient en batterie dans les derniers jours du siége.

Indépendamment de ces pièces, la marine fournit encore, pour les besoins du siége, les approvisionnements et les poudres dont la flotte pouvait disposer sans compromettre son propre service.

Enfin, la défense se prolongeant, l'Empereur ordonna d'expédier de France un équipage de 400 mortiers, approvisionnés chacun à 1,000 coups, destinés à bombarder la place sans relâche et à protéger nos attaques en rendant les ouvrages russes inhabitables.

L'emploi d'un moyen aussi formidable promettait des résultats immédiats et décisifs. Qu'on se figure, en effet, ce qu'auraient produit 400 mortiers approvisionnés chacun à 1,000 coups, pouvant lancer pendant vingt jours et vingt nuits plus de 830 bombes par heure, ou environ 14 bombes par minute !

Une partie seulement de ces mortiers fut mise en batterie, la place ayant été prise avant que tous fussent arrivés à destination.

L'organisation de ces divers équipages, leur réunion à Marseille et leur embarquement rencontrèrent de nombreuses difficultés : elles furent surmontées, grâce aux ressources accumulées dans les places de l'Empire et à l'activité déployée dans nos arsenaux. Des ateliers, où se confectionnaient les cartouches et les fusées de projectiles creux et où se préparaient les munitions des bouches à feu, furent organisés dans les places situées à proximité des voies ferrées et travaillèrent sans interruption.

Les consommations de poudre atteignant des proportions énormes, les poudreries donnèrent à leur fabrication une extension inusitée et livrèrent en 1854 jusqu'à 1,600.000 kilogrammes de poudre de guerre. En 1855, elles purent en livrer 3,250,000 kilogrammes, sans ralentir la fabrication des poudres de chasse et de mine.

Le transport de cet immense matériel, dont le poids a dépassé 50 millions de kilogrammes, eût été certainement impossible il y a peu d'années encore. Mais avec le réseau de chemins de fer qui relie Marseille aux principales villes de l'Empire, les impossibilités disparurent, et nul retard ne vint troubler la continuité des embarquements.

Tels furent, d'ailleurs, les soins qui présidèrent à ces opérations, que 3 millions de kilogrammes de poudre, 70 millions de cartouches d'infanterie, 270,000 cartouches montées pour bouches à feu de campagne, 7 à 8,000 fusées de guerre toutes chargées et une immense quantité d'artifices arrivèrent à destination, sans que l'on ait eu à déplorer le moindre accident.

L'artillerie, secondée par 6 compagnies du régiment d'artillerie de marine, par les marins de la flotte mis à terre, et par les auxiliaires de l'infanterie, construisit, arma et servit, pendant le siége, 118 batteries établies sur un terrain hérissé d'obstacles et sous le feu incessant de la place, en même temps qu'elle assurait l'armement et l'approvisionnement des redoutes des camps et des lignes de Kamiesch. Ces batteries exigèrent l'emploi de 800,000 sacs à terre et de 50,000 gabions. Au jour de l'assaut, leur armement se composait de 620 bouches à feu. Elles avaient tiré plus de 1,100,000 coups de canon, et consommé plus de 3 millions de kilogrammes de poudre.

Malgré le chiffre de ces consommations, dont l'histoire n'offre aucun autre exemple, le parc d'artillerie, au moment de la prise de Sébastopol, restait approvisionné à raison de 8 à 900 coups par pièce, sans compter tout le matériel que les ports de France expédiaient journellement. Une quarantaine de bouches à feu seulement étaient hors de service. Les ressources de l'artillerie lui permettaient donc de continuer la lutte pendant bien longtemps encore.

Le matériel ramené en France peut être évalué à 50 millions de kilogrammes, dont 38 millions de matériel français et 12 millions de matériel russe.

MATERIEL DU GENIE.

Outils et Approvisionnements divers.	Quantités.	Poids. Kilog.
Outils de terrassiers.	72,000	165,000
Outils de carriers.	7,400	22,000
Outils de bûcherons.	6,300	12,500
Outils de mineurs,	1,800	15,200
Crocs, fourches et dragues pour les sapes.	200	600
Armures de sapeurs.	12	230
Brouettes.	800	18,200
Civières à bras.	1,700	20,000
Sacs à terre.	920,000	230,000
Palissades.	8,000	525,000
Chevaux de frise.	50	15,000
Manches d'outils.	80,000	35,000
Outils d'ouvriers d'art.	16,900	16,300
Machines et Engins.		
Norias.	8	4,000
Sonnette complète.	1	1,670
Ventilateurs en bois.	5	250
Machines à camouflet.	3	900
Moulins à bras.	5	150
Mouton à bras.	1	50
Cabestans.	4	360
Cordages divers.	,,	7,250
Echelles diverses.	250	6,250
Pompes à incendie.	10	2,000
Matériel roulant et objets de rechange.		
Voitures diverses.	87	69,860
Caisses diverses.	210	12,600
Roues, essieux et autres objets de rechange.	325	4,450
Matériaux et objets divers de consommation.		
Bois divers pour travaux de siége et construction d'hôpitaux provisoires, baraques, chauffoirs, magazins pour les vivres et provisions.	16,980 Mètres cubes.	7,971,600
Fer.	,,	10,870
Acier.	,,	1,550
Tôle.	,,	1,830
Broches, clous et pointes.	,,	54,000
Goudron.	,,	223,000
Bougies.	,,	4,200
Charbon de terre.	,,	76,000
Poudre de mine.	,,	90,400
Toiles diverses pour fermetures et couvertures de baraques. (dont 4,100 mètres de toile goudronnée).	21,600 Mètres carrés.	10,000
Instruments de lever.	400	250
Baraquement.		
Baraques pour officiers et soldats.	2,900	4,047,000
Baraques pour écuries.	210	400,000
Poêles en fonte.	2,800	84,000
Total.		14,159,520

Environ 14,000 tonneaux.

Poids approximatif du matériel rapporté en France après la campagne. 2,400,000
ou 2,400 tonneaux.

OBSERVATIONS.

Le matériel roulant, les gros outils, les instruments de sape et de mine ont été fournis en très-grande partie par les arsenaux du génie de Metz et d'Alger, et le surplus par l'industrie privée. Ce matériel, au moins cinq fois plus considérable que celui qu'exige le siége d'une grande place dans des conditions ordinaires, a commencé à être embarqué dès le mois de Mars 1854, et les derniers envois ont eu lieu en Août 1855.

Les approvisionnements en planches, madriers, fer, cuivre, tôle, etc., ont été achetés dans le commerce à Lyon, Toulon, Marseille, Constantinople et Trieste. Ces matériaux ont été employés non seulement dans les travaux du siége, mais ils ont servi aussi pour construire sur place des hôpitaux provisoires et des magasins pour les vivres et les munitions.

Sur les 220,000 sacs à terre expédiés en Crimée, 300,000 ont été tirés des magasins de l'Etat, et le surplus a été acheté au commerce à Paris, Lyon, Metz, Toulon, Marseille et Constantinople.

Dès qu'il fut reconnu que l'armée passerait l'hiver sous les murs de Sébastopol, l'empereur ordonna que des abris fussent envoyés en Orient. Des baraques pour les hommes et des hangars pour les chevaux furent aussitôt commandés en France et en Angleterre.

1,050 baraques, pouvant abriter 30,000 hommes, ont été confectionnées à Toulon et à Marseille en Janvier 1855, et l'embarquement commençait dès le mois suivant.

1,850 baraques, pouvant contenir 45,000 hommes ont été commandées en Angleterre dans les premiers jours de Décembre 1854, et sont parties de Southampton dans le courant du mois suivant.

Chaque baraque était pourvue d'un poêle.

Des abris-écuries, pour environ 10,000 chevaux, ont été commandés à Paris et embarqués à Marseille en Janvier 1855.

En outre, un approvisionnement de 50,000 longerons en bois de sapin, de 20,000 madriers, 100,000 planches et 9,000 boulons a été acheté à Marseille et expédié dans le courant de 1855 pour l'établissement des baraques-chauffoirs.

Le service du génie, dans ce siége à jamais mémorable, a exécuté 80 kilomètres (20 lieues) de tranchée, employé 80,000 gabions, 60,000 fascines et près d'un million de sacs à terre. Il a fait construire, sur les crêtes qui protégeaient la droite de nos attaques des ouvrages défensifs ayant ensemble plus de 8,000 mètres de développement, et sur la gauche un retranchement continu de 8,000 mètres aussi de longueur, presque en ligne droite, appelé *lignes de Kamiesch*, s'appuyant par ses deux extrémités à la mer, couvrant contre toutes les éventualités de la guerre les baies de Kamiesch et de Kazatch et nous assurant la possession d'une vaste place de dépôt où se trouvaient abritées toutes les ressources de l'armée.

Ces lignes étaient formées d'un épais parapet précédé d'un fossé creusé dans le roc et flanqué par huit fortes redoutes armées de pièces de gros calibre.

Mais ce qui fait surtout qu'aucun autre siége ne peut être comparé à celui de Sébastopol, c'est l'immense difficulté des travaux de cheminement creusés presque en totalité dans le roc à l'aide de la poudre, et devant une place qui, pour garnison, avait une véritable armée, constamment renouvelée et librement ravitaillée.

Il a fallu aussi triompher des obstacles qu'opposait une défense souterraine habilement disposée et formée d'un immense réseau de plus de 6,000 mètres de galeries de mine établies dans le roc sur plusieurs étages de hauteur, dont les plus bas atteignaient 16 mètres de profondeur au-dessous du sol.

SUBSISTANCES MILITAIRES—CHAUFFAGE—FOURRAGES.

	Quantités.		Conversion en Tonneaux.	
VIVRES.				
Biscuit.	12,792,300	kil.	25,584	60
Farines.	22,105,000		22,436	57
Légumes secs.	193,000		196	86
Légumes comprimés.	341,900		341	90
Riz.	3,586,800		3,658	53
Sel.	79,400		93	37
Sucre.	2,763,100		5,058	28
Café.	2,149,600		2,436	21
Lard salé.	5,242,400		8,733	83
Bœuf salé.	518,200		863	32
Conserves de bœuf.	3,053,700		3,197	22
Saindoux	50,000		6	,,
Viande sur pied.	10,000	têtes.	35,000	,,
Vin.	116,567	hect.	12,838	,,
Eau-de-vie et rhum.	13,766		1,520	,,
CHAUFFAGE.				
Bois.	1,944,900	kil.	9,722	,,
Charbon de terre.	15,772,300		15,772	30
FOURRAGES.				
Foins.	77,403,400		229,998	60
Orge ou avoine.	83,700,000		119,571	43
			497,029	02
Objets mobiliers envoyés isolément (approximativement).			1,500	,,
Total général pour le service des subsistances.			498,529	02

Soit en chiffres ronds 500,000 tonneaux.

On évalue à 500,000 tonneaux les quantités de vivres non consommées et de matériel rapportées en France.

OBSERVATIONS.

Biscuits.—Les quantités expédiées ont été obtenues tant au moyen d'une fabrication réglementaire dans les manutentions militaires de Paris, Rouen, le Havre, Brest, Bordeaux, Bayonne, Marseille, Toulon, Montpellier, Perpignan, Alger et Oran, qu'au moyen d'achats faits en Angleterre et en France à la maison Packam. Deux cent soixante mille caisses ont été nécessaires pour les contenir.

Farines.—Les farines ont été expédiées des places de Marseille, Toulon, Montpellier, Perpignan, Bordeaux, Alger et Oran.

Légumes comprimées.—Fabriqués par la maison Chollet et expédiés en totalité de Paris.

Riz.—A été expédié en majeure partie décortiqué. Les achats ont été faits à Londres, à Bordeaux et surtout au Havre.

Café.—Mêmes lieux d'expédition que le riz.

Sucre.—A l'exception de quelques chargements faits à Bordeaux et à Marseille, la totalité a été expédiée du Havre en sucres blancs et en pains.

Salaisons.—Achetées en majeure partie en Angleterre ; le complément a été cédé par le département de la marine.

Conserves de bœuf en boîtes.—A l'exception de faibles quantités fabriquées en France par M. de Lignac (viande comprimée), et par M. Appert (bœuf avec bouillon), presque tout le reste a été confectionné en Angleterre. Dans la quantité de 3,053,700 kilogrammes de conserves de bœuf, sont compris 404,000 kilogrammes de viande en poudre, représentant à peu près 600,000 rations.

Viande sur pied.—4,000 bœufs tirés de Trieste; 1,500 de l'Algérie; 4,500 de la Caramanie (port du Macri).

Vins.—Les vins de malades ont été tirés de Bordeaux et Perpignan; les vins de troupe, du Var et de l'Hérault.

Eau-de-vie et rhum.—Vu la cherté de l'eau-de-vie et sa qualité douteuse, les approvisionnements ont été faits de préférence en rhum des meilleures provenances. L'achat en a été fait à Londres et à Marseille.

Charbon de terre.—Tiré d'Angleterre.

Bois.—Embarqué comme fardage, conséquemment sans frais.

Foin.—Les expéditions ont été faites de Nantes, Marseille, Montpellier, Perpignan, Alger, Mostaganem, Bône, Philippeville; et à l'étranger, d'Anvers, Gênes, Livourne, Naples, Messine et Trieste.

Orge et avoine.—Les versements ont été effectués du Havre, de Marseille et des ports de l'Algérie; à l'étranger, d'Angleterre, d'Espagne, du Maroc, d'Italie, d'Egypte et de Syrie.

Matériel.—Sacherie.—Un million de sacs expédiés, soit comme contenant des denrées susmentionnées, soit comme approvisionnements.

Fours.—Cent cinquante fours, dont soixante portatifs.

Prélarts.—1,700 prélarts représentant une superficie de 204 mille mètres carrés.

Presses à foin.—137 de divers systèmes. Ces appareils ont été expédiés pour le pressage des foins achetés en Turquie, indépendamment des quantités portées au tableau ci-contre.

1,800 voyages de navires à chargement complet ont été nécessaires pour transporter en Orient les denrées et matières portées ci-contre. Les chargements ont été effectués, savoir:

460 en France,
566 en Algérie,
4 en Espagne,
77 en Angleterre,
5 en Belgique,
600 en Italie,
88 en Egypte et en Syrie.

Total égal. . . 1,800

HABILLEMENT—CAMPEMENT—HARNACHEMENT.

Habillement et Equipement.

	Nombre d'objets.
Ceintures de flanelle.	654,882
Sacs tente-abri.	347,319
Couvertures de campement.	371,787
Chemises de coton.	354,529
Guêtres en cuir (paires).	42,527
Guêtres en toile (paires).	163,449
Pantalons de toile grise.	9,000

Souliers (paires)	328,209
Bottes éperonnées (paires)	32,396
Caleçons	132,336
Blouses de cuisine	200
Blouses d'écurie	25,010
Pantalons de cuisine	200
Casquettes de chasseurs d'Afrique	717
Couvre-casques	3,000
Bretelles de fusil	525
Montants de tente-abri	183,265
Visières de bonnet ou shakos	2,000
Boutons de diverses armes	20,620
Cravates de coton	200,000

Effets Spéciaux.

Sabots (paires)	238,597
Chaussons de laine (paires)	189,162
Capotes à collet et à capuchon	251,399
Bas en laine (paires)	220,000
Gants en laine (paires)	215,000
Chachias	253,576
Guêtres-houzeaux en peau de mouton (paires)	90,000
Guêtres bulgares (paires)	163,739
Paletots en peau de mouton	15,000

Effets de Campement.

Cales	16,448
Fers de lance	60
Goujons	15,512
Montants de tente de conseil	68
Montants de tente d'officier ou de troupe	30,952
Traverses de tente de conseil	21
Traverses de tente à seize hommes	9,199
Traverses de tente d'officiers	1,500
Traverses de tente conique à vingt hommes	6,500
Tablettes avec porte-manteaux	71,209
Tablettes sans porte-manteaux	18
Piquets de tente, grands et petits	567,971
Pliants	3,428
Tables	24
Rideaux	4
Maillets	23,316
Bois de manteaux d'armes de compagnie	640
Bois de manteaux d'armes de piquet	30
Toiles de manteaux d'armes de compagnie	500
Toiles de manteaux d'armes de piquet	14
Grands bidons	40,973
Petits bidons en fer-blanc avec courroies	289,714
Gamelles	43,196
Marmites	46,981
Etuis de bidons	1,019
Etuis de gamelles	1,061

Etuis de marmites.	1,019
Bretelles de bidons et de marmites.	1,812
Bretelles de gamelles.	692
Faucilles.	16,400
Faulx.	1,499
Haches.	17,236
Pelles.	15,748
Pioches.	16,721
Serpes.	8,341
Cordes à piquet de cavalerie.	mètres. 1,412

Effets de Harnachement.

Clous à ferrer.	6,193,400
Fers de cheval.	817,216
Bissacs garnis de cuir.	16,222
Entraves.	7,567
Cordes d'entraves.	310
Bridons avec mors.	2,039
Selles de cavalerie légère (nouveau modèle).	646
Selles de cavalerie légère (ancien modèle).	1,004
Mors de bride.	900
Licols de parade.	779
Filets doubles.	368

OBSERVATIONS.

Les événemens de la guerre ont placé l'armée d'Orient dans un pays à peu près sans ressources, et sous un climat exceptionnel; il a fallu lui envoyer de France tout ce qui était nécessaire pour la vêtir et l'abriter, et jusqu'aux clous propres au ferrage de ses chevaux.

L'âpreté de la température sur les plateaux de la Chersonèse a obligé d'envoyer, non seulement tous les effets d'habillement et de campement d'un usage réglementaire, mais, en outre, une série complète de vêtements d'hiver qui constituait pour chaque soldat un habillement supplémentaire composé des objets suivants:

Savoir :—Capote à capuchon et à collet en drap ;
Guêtres bulgares en drap ;
Sabots avec chaussons en laine ;
Gants, bas et chachia en laine.

Tous les hommes de garde et ceux qui étaient employés à un service extraordinaire avaient en outre un paletot en peau de mouton et des guêtres-houzeaux en peau de mouton.

Ces effets, envoyés en 1854 et au commencement de 1855, ont dû, comme les vêtements ordinaires, être renouvelés pour la plupart, afin de parer aux besoins de l'hiver de 1855 à 1856.

Les effets de campement existant dans les magasins de l'Etat à l'origine de la guerre étaient suffisants pour les besoins d'une armée en campagne de 70 à 80,000 hommes seulement; il a donc fallu procéder en toute hâte à la confection d'autres effets de campement en quantités considérables, au moyen de marchés que l'industrie privée a réalisés en temps opportun. Tous ces objets sont parvenus sans avaries, bien qu'ils constituassent un matériel immense, presque toujours très-encombrant.

Le nombre de tentes avec leurs accessoires expédiés en Orient pouvait suffire au campement de 280,000 hommes, sans compter celles qui étaient affectées aux officiers.

Les premières tentes étaient à deux montants et en forme de toit; mais l'expérience du climat de la Crimée, et surtout l'ouragan du 14 Novembre 1854, ont fait reconnaître que la tente de forme conique à un seul montant, usitée en Turquie, offrait plus de résistance aux intempéries des saisons, et on a adopté cette forme pour toutes les tentes envoyées en 1855. La toile de chanvre n'a pas été exclusivement employée pour la confection des tentes; on a fait usage aussi de la toile de coton, dont on s'est bien trouvé, et dont l'emploi a diminué la dépense et le poids.

L'envoi des faux et faucilles a permis de récolter le fourrage qu'on a trouvé dans la Dobrudscha d'abord, et ensuite dans la Chersonèse.

Une partie assez importante du matériel du campement et des effets spéciaux d'habillement n'a pas été mise en service, et a été réexpédiée d'Orient sur les magasins de France et d'Algérie.

On peut évaluer à 42,000 tonneaux environ le volume du matériel porté ci-dessus. Les magasins particuliers dont les corps ne se séparent jamais en campagne ne sont point compris dans leur évaluation; leur poids total s'est élevé à 7,300 tonneaux.

L'ensemble des objets réexpédiés d'Orient sur la France et sur l'Algérie représente à peu près 8,000 tonneaux.

SERVICE HOSPITALIER.

Matériel d'Hopitaux Mobiles.

	Quantités.		
	Expédiées de France.	Achetées en Orient.	TOTAL.
Couchettes ou châlits en fer. . . .	12,000	,,	lits.
Couchettes ou châlits en bois. . . .	,,	15,000	(A) 27,000
Couvertures en laine.	32,000	7,500	39,500
Couvertures en coton.	,,	3,500	3,500
Laine à matelas et à traversins. . . .	,,	kilogr. 325,000	matelas. 30,000
Matériel complet pour hôpitaux de 500 malades chacun.	23	7	(B) 30
Pharmacies complètes, ustensiles et médicaments pour hôpitaux de 500 malades chacun.	30	,,	30
Mobiliers de chapelle pour les hôpitaux militaires.	14	,,	(C) 14
Matériel d'Ambulance.			
Matériel d'ambulance légère (modèle d'Afrique) pour 12,000 hommes chacun. . .	2	,,	2
Chargements de caissons d'ambulance, à raison de 5 par division d'infanterie. . .	110	,,	(D) 110
Cantines régimentaires d'ambulance, sacs et sacoches d'ambulance (paires). . . .	35	,,	35
Boites d'instruments de chirurgie de diverses natures.	106	,,	106
Caisses à amputation et à trépan contenues dans les cantines d'ambulance. . .	150	,,	150
Caisses à amputation contenues dans les caissons d'ambulance.	220	,,	220
Caisses d'instruments contenues dans les hôpitaux militaires.	70	,,	70

Objets de Pansement.

	kil.		TOTAL. kil.
Grand linge à pansement.	57,000	,,	57,000
Petit linge à pansement.	76,000	,,	76,000
Bandes roulées.	32,000	,,	32,000
Charpie.	49,000	,,	49,000
Linge à pansement assorti, contenu dans les hôpitaux mobiles, les caissons et cantines.	80,000	,,	80,000
	294,000	,,	294,000
Bandages herniaires.	5,000	,,	5,000

Denrées Alimentaires.

	kil.		kil.
Lait concentré.	8,000	,,	(E) 8,000
Essence de bouillon concentré.	1,000	,,	(E) 1,000
Bœuf bouilli.	2,800	,,	2,800
Gluten granulé.	3,000	,,	3,000
Conserves Chollet (Julienne). pour soldats.	51,000	,,	(E) 51,000
pour officiers.	1,600	,,	1,600
Légumes divers conservés.	25,000	,,	(E) 25,000

OBSERVATIONS.

(A) L'ensemble de ces approvisionnements, complétés par des achats sur place, a constitué, dans la ville de Constantinople, un service aussi régulier que celui qui fonctionne dans les hôpitaux de l'intérieur de la France.

Les 27,000 lits réunis dans les premiers mois de la guerre présentent un matériel plus considérable que la fixation totale des lits existant dans les hôpitaux militaires permanents en France, où l'on ne compte que 19,000 lits, ainsi repartis :

Malades.	16,500 lits.
Soldats infirmiers.	2,500
Ensemble.	19,000

L'administration a pourvu à la réunion de ce matériel, d'abord par des prélèvements immédiats dans les magasins de réserve, ensuite par des commandes que l'industrie privée a exécutées avec une grande promptitude.

(B) La nomenclature détaillée des effets affectés a ces hôpitaux de 500 malades, est indiquée dans le réglement du 1er Avril 1831 ; elle comporte, par hôpital, un poids de 12,000 kilogrammes, non compris les lits en fer ou en bois, ce qui forme, pour les trente hôpitaux installés en Orient, un poids de 360,000 kilogrammes.

(c) D'après les ordres de l'Empereur, le service religieux avait été assuré, et les secours spirituels n'ont jamais manqué à nos soldats. Les aumôniers ont donné des preuves du plus grand dévouement, et, comme les admirables filles de Saint-Vincent de Paul, ils ont soutenu dans les ambulances et dans les hôpitaux le moral de nos malades et de nos blessés.

Le service religieux était dirigé à l'armée par des prêtres catholiques. Les consistoires centraux de l'église réformée et du culte israélite avaient envoyé auprès de leurs coreligionnaires des ministres et des rabbins.

Le service catholique des quatorze hôpitaux de Constantinople était confié à la congrégation des Lazaristes, qui a un collége dans cette ville et dont l'influence se fait vivement sentir dans tout l'Orient. Cette mesure était d'ailleurs une conséquence de l'installation dans nos hôpitaux des sœurs de Saint-Vincent de Paul, dont les Lazaristes sont les supérieurs.

(D) Chaque caisson d'ambulance comprend 2,000 pansements. Les 110 caissons formaient donc un approvisionnement de bataille de 220,000 pansements, que l'on pouvait remplacer au fur et à mesure des consommations par des envois faits de Constantinople.

(E) L'expérience du lait concentré (procédé de Lignac), de l'essence de bouillon concentré, tiré d'Angleterre ; des légumes conservés (procédé Chollet et Masson), a eu un succès complet. Ces produits sont désormais acquis aux approvisionnements hospitaliers.

L'ensemble des expéditions de matériel faites en Orient pour le service hospitalier représente un volume de 6,430 tonneaux. Le matériel ramené, tant en France qu'en Algérie, est environ du tiers des expéditions, soit de 2,150 tonneaux.

EQUIPAGES MILITAIRES.

		Quantités.	Poids. Kilogr.
Caissons de 1,200 rations		775	1,388,150
Caissons de 1,600 rations		143	122,551
Caissons d'ambulance		118	116,820
Chariots de parc sans exhaussement		259	212,121
Chariots de parc avec exhaussement		218	180,940
Forges ancien modèle		22	12,100
Forges nouveau modèle		48	44,640
Harnais de trait (avec garniture de tête complète)	de devant porteur	1,127	148,676
	de devant sous verge	1,148	
	de derrière porteur	1,236	
	de derrière sous verge	1,285	
Selles complètes d'attelage		1,811	214,080
Selles complètes de sous-officier et cavalier		1,732	
Selles complètes d'adjudant sous officier		25	
Bâts de mulet		2,971	89,130
Couvertures de cheval		16,311	29,900
Forges portatives		21	1,995
Paires de cacolets		2,760	27,600
Paires de litières		849	36,507
Rechanges de toute nature, tels que boîtes à graisse, caisses à outils, roues ferrées, timons ferrés, et non ferrés, bridons, licols, cordes de charge, etc.		„	1,500,000
Matières premières : bois, fers, etc.		„	1,200,000
Charrettes marseillaises avec harnais		300	200,000
Charrettes maltaises avec harnais		400	
Charrettes dites *bouhoure* avec harnais		400	
Total		Kilogr. (A)	5,525,210

(A) Ce total représente, comme il est dit plus haut, 7,956 tonneaux de mer. Un tiers de ce matériel environ est devenu hors de service et a été vendu ; mais une grande partie des voitures et autres objets construits en Turquie a été portée en Algérie ; en sorte que l'ensemble du matériel ayant fait retour peut être évalué à 7,000 tonneaux.

OBSERVATIONS.

Malgré son effectif élevé (11,000 hommes et 8,000 chevaux ou mulets), le train des équipages militaires affecté à l'armée d'Orient aurait été dans l'impossibilité d'assurer la complète exécution de tous les services administratifs, si on ne lui avait adjoint plusieurs compagnies provisoirès auxiliaires composées, tant pour le personnel que pour le matériel, d'éléments étrangers au service du train proprement dit. Ces compagnies furent recrutées les unes en Orient même et les autres en France.

Le matériel auxiliaire a consisté principalement en :

400 voitures maltaises exécutées à Malte par l'entremise du consul de France ;
300 charrettes marseillaises expédiées de France ;
100 voitures dites *Bouhoure*, dont le modèle avait été approuvé par l'Empereur ;
1,600 voitures dites *arabas* et *tekis*, dont l'achat a été effectué en Turquie ou qui ont été construites à Constantinople par les ouvriers militaires attachés au parc de réserve des équipages militaires.

Le nombre de ces compagnies auxiliaires, dont la création n'a d'ailleurs eu lieu que successivement et au fur et à mesure des besoins, était encore, à la fin de la campagne, de dix-neuf, présentant un effectif de 2,728 conducteurs indigènes, 11,346 animaux (chevaux, mulets, bœufs et bufles) et 2,425 voitures de toutes sortes. Ces ressources ont contribué de la manière la plus efficace à la bonne exécution du service des transports.

Le matériel et le harnachement du service des équipages auxiliares expédiés sur l'Orient représentait 7,956 tonneaux d'encombrement.

Tous ces objets n'ont pas été employés à l'exécution des divers services de l'armée ; mais une sage prévoyance commandait d'établir, dans un lieu à proximité du théâtre de la guerre, une réserve considérable, de manière à pouvoir faire face instantanément aux besoins qui pourraient se manifester.

Tel a été le motif de la formation du parc de réserve des équipages militaires à Constantinople, dès le début de la campagne. On peut se figurer quelle a pu être l'importance de cette réserve, puisqu'à la fin de la guerre elle consistait encore en :

296 caissons, 119 chariots de parc, 31 forges, 166 attelages à quatre chevaux, 714 selles, schabraques, etc., 398 bâts de mulets, 9,155 couvertures, 398 paires de cacolets, 578 paires de litières.

Cet établissement, dont la direction a été d'abord confiée a un capitaine, puis à un chef d'escadron de l'état-major des parcs, n'a cessé de rendre les plus utiles services pendant toute la durée de la guerre. Non seulement il a été chargé de l'exécution des grosses réparations à faire au matériel roulant, mais encore il a pu, par sa présence sur les lieux, contribuer à la prompte régularisation des comptabilités en deniers et en matières.

ÉTAT CIVIL—JUSTICE—ADMINISTRATION DU TERRITOIRE OCCUPÉ.

Un des premiers soins du commandement, lors de la formation de l'armée, avait été d'assurer dans l'intérêt des familles, l'état civil des militaires, à leur corps, à l'hôpital, et jusque sur le champ de bataille.

En même temps, des prévôtés et des conseils de guerre étaient établis dans chaque division pour maintenir l'ordre et la discipline. Les statisques de la justice militaire prouvent qu'à aucune époque l'autorité supérieure n'a eu à faire un plus rare emploi des moyens de répression que la loi met à sa disposition.

Des interprètes commissionnés par le ministre de la guerre assuraient les relations nécessaires entre les diverses nations engagées dans la lutte.

Enfin, dès les premiers jours de l'installation à Kamiesch, une administration générale avait été organisée, un conseil de prud'hommes avaient été constitués. Bientôt un service de police et de salubrité fut créé, et les nombreux nationaux, ainsi que les étrangers attirés à la suite de l'armée, trouvèrent dans la cité improvisée une protection constante et efficace.

SERVICE DE LA TRÉSORERIE ET DES POSTES.

Le personnel de la trésorerie de l'armée était en même temps chargé des postes ; ce double service était si complétement organisé que les militaires de tous grades ont reçu leur solde et les prestations en nature aussi régulièrement et aussi exactement que s'ils eussent été dans une garnison de France, et qu'ils ont pu entretenir avec leurs familles une correspondance pour ainsi dire journalière.

Ce personnel, placé sous les ordres d'un payeur général, et composé de 6 payeurs principaux, 8 payeurs particuliers et 75 payeurs adjoints et agents secondaires, a constamment satisfait à tous les besoins, tant pour les corps d'armée et les divisions près de Sébastopol que sur les points les plus éloignés occupés temporairement par nos troupes.

Le matériel fut tiré des équipages militaires, ainsi que le nombre de soldats nécessaire pour le conduire ; il se composait de 12 caissons ou chariots, 104 chevaux de trait et de selle, 20 mulets de bât, employés selon les besoins et les circonstances.

Le service de la trésorerie a été assuré, comme dans les campagnes antérieures, par les moyens suivants : 1o envois directs de fonds ; 2o réalisation sur place, par émission de traites. Ce dernier moyen a donné des résultats importants, et la faveur dont les traites du Trésor ont joui en Orient a été telle, qu'il a fallu crééer des coupures de 20,000 et de 10,000 fr. Les émissions se sont élevées jusqu'à 12 millions par mois.

Les paiements effectués en Orient depuis le mois d'Avril 1854, sur les crédits délégués par le ministère de la guerre, s'élevaient, au 1er Juillet 1856, à 285,646,160 fr. 45 c., dont 275,457,340 fr. 64 c. sur mandats de l'intendance militaire, 1,914,265 fr. 16 c. sur mandats des chefs du service de l'artillerie, et 8,274,554 fr. 65 c. sur mandats des chefs de service du génie.

Les dépenses de la guerre ont toujours été vérifiées, liquidées, soldées et définitivement apurées par exercice, dans les délais réglementaires fixés pour les dépenses du pied de paix, solution avantageuse à tous les points de vue et d'autant plus remarquable que, dans aucune des guerres précédentes, semblable résultat n'avait pu être obtenu.

SERVICE TÉLÉGRAPHIQUE.

Dès le commencement de la campagne, on avait compris la nécessité d'établir entre le quartier général et les différents corps détachés, des communications qui assurassent la transmission rapide des ordres et l'ensemble des mouvements.

Dans ce but, un personnel de l'administration des lignes télégraphiques, composé de 2 inspecteurs, 5 directeurs, 4 stationnaires électriques et 47 stationnaires aériens, fut attaché à l'expédition.

Muni de 16 télégraphes aériens portatifs susceptibles de se monter et de se démonter facilement et en peu de temps, ce personnel fut réparti de manière à mettre le général en chef en rapport immédiat avec les différentes fractions de son armée.

Pendant le siége, le gouvernement anglais ayant eu la pensée de relier par un câble électrique sous-marin Balaklava à Varna, l'Empereur ordonna aussitôt de rattacher Varna au réseau télégraphique allemand.

En peu de temps, et malgré les difficultés de toute nature, la ligne de Buckarest à Varna, sur un parcours de 60 lieues, se trouva complétement établie et les communications furent ouvertes quelques jours avant l'achèvement du câble sous-marin.

Trois inspecteurs, 4 directeurs, et 30 stationnaires assurèrent dans les quatre postes de Buckarest, Routschouk, Schumla et Varna un service de transmissions qui plaçait l'armée à quelques heures de Paris.

IMPRIMERIE.

Une imprimerie lithographique installée au quartier général avait d'abord suffi aux besoins du service ; mais, dès le commencement du siége, le nombre toujours croissant des ordres à transmettre, et la nécessité de les faire parvenir sans délais aux différents corps de l'armée, déterminèrent le général en chef à demander qu'un service typographique complet fût expédié en Crimée.

Cet envoi eut lieu par les soins du directeur de l'imprimerie impériale, et, jusqu'à l'évacuation de la Crimée, un prote et deux ouvriers typographes sont restés au quartier général.

TROISIÈME PARTIE.

TRANSPORTS MARITIMES.

La marine impériale, sans cesser de faire face aux nombreux services dont elle est restée chargée, a concouru ainsi qu'il suit aux transports militaires :

11	vaisseaux mixtes et à vapeur,
21	vaisseaux à voiles,
19	frégates à voiles;
24	transports mixtes et à voiles,
19	frégates à vapeur,
21	corvettes,
17	avisos.

En tout 132 bâtiments, qui ont fait 905 voyages et ont transporté, pour l'armée de terre seulement, soit pour l'aller, soit pour le retour, 273,780 hommes, 4,266 chevaux et 116,661 tonneaux de matériel.

Le gouvernement anglais a mis à la disposition de l'Empereur 8 navires de la marine royale et 42 navires du commerce nolisés par l'amirauté, qui ont transporté ensemble en Orient 38,353 hommes, 1,972 chevaux et 6,624 tonneaux de matériel.

L'administration de la guerre a nolisé, en 1854 et 1855, 66 vapeurs et 1,198 navires à voiles de toutes dimensions. Les 66 vapeurs et 22 grands clippers formaient une espèce de flotte qui a fait jusqu'à la fin de la guerre un va-et-vient permanent entre l'Orient et les ports où étaient réunis les approvisionnements. Enfin les paquebots de la Compagnie des Messageries impériales, par suite de marchés conclus dès le commencement de la guerre, ont transporté des troupes à pied et du matériel, à raison de deux voyages par semaine.

Pour le retour de l'armée, l'administration a continué à employer 48 navires à vapeur et 253 navires à voiles, dont 14 grands clippers.

Au total, les transports effectués par les soins de l'administration de la guerre se sont élevés à 224,270 hommes, 44,736 chevaux ou mulets, et 601,251 tonneaux de matériel.

En dehors des moyens de transport indiqués ci-dessus, l'intendant général en Crimée et l'intendant militaire en mission à Constantinople, ont nolisé un grand nombre de navires pour le ravitaillement de l'armée. Ces bâtiments étaient exclusivement employés à porter en Crimée les vivres et les fourrages achetés sur le littoral de la Mer Noire et dans toute la Turquie.

L'ensemble des transports maritimes peut se résumer ainsi:

	NOMBRES		
	d'hommes.	de chevaux.	de tonneaux.
Envoyés en Orient.	309,268	41,974	597,686
Revenus d'Orient.	227,135	9,000	126,850
Totaux pour l'aller et le retour. . . .	536,403	50,974	724,536

Les totaux ci-dessous se décomposent de la manière suivante:

	NOMBRES		
	d'hommes.	de chevaux.	de tonneaux.
Transports faits par la marine impériale. . . .	273,780	4,266	116,661
Transports faits par les bâtiments anglais. . .	38,353	1,972	6,624
Transports faits par l'administration de la guerre au moyen de la flotte commerciale et des paquebots des messageries.	224,270	44,736	601,251
Totaux pareils.	536,403	50,974	724,536

Le personnel et le matériel embarqués à Marseille y étaient arrivés, en très-grande partie, par le chemin de fer de Paris à la Méditerranée ; si cette voie ferrée n'avait pas existé, les opérations de la guerre auraient certainement beaucoup perdu de leur ensemble et de leur rapidité.

Sa Majesté l'Empereur, en reportant sa pensée à quelques années en arrière, pourra se rappeler avec satisfaction que l'un des premiers actes de son énergique initiave a été de lever les obstacles opposés jusqu'alors à l'achèvement de cette grande ligne, qui devait si promptement contribuer aux éclatants succès de son armée.

Le maréchal de France ministre secrétaire
d'Etat au département de la guerre,

VAILLANT.

PAPER V.

ACCOUNT OF THE DEMOLITIONS OF THE DOCKS AT SEBASTOPOL,

EXECUTED BY THE FRENCH UNDER THE DIRECTIONS OF GENERAL FROSSARD, COMMANDANT DU CORPS DU GÉNIE.

Translated by Lieut. Col. Bainbrigge, R.E., by Permission.

GENERAL DESCRIPTION.

The lithographed Russian plans of the Docks at Sebastopol afforded every information relative to the construction of that magnificent maritime establishment, the destruction of which by mining was determined on.

It consisted of five dry docks, three of which were intended for ships of the line and two for frigates. The latter were separated from the others by an immense basin, which could receive the five vessels under repair at the same time; and from this the latter were brought into their respective docks. The two docks for frigates were placed on each side of the three locks by which a communication between the sea and the basin was effected. The waters of the Tchernaya were conducted into the latter by a canal passing through several tunnels and over several aqueducts: in case of a deficiency of water in that river, the basin could be filled with water from the sea by means of a steam-pump, forcing it into that end of the canal next to the basin.

The height of the sills of the docks above the level of the sea was such as to allow of emptying and filling them, as well as the basin, by means of culverts provided with sluice gates. Gates, strengthened by transoms and posts of cast iron, and covered with strong iron plates, closed the locks; and similar ones closed the docks and enabled them to be emptied.

The three docks for line-of-battle ships* and the westernmost one of those intended for frigates had been excavated in the rock, and revetted with good limestone masonry, having a facing of the same material and a coping of granite: the floors were constructed with cut stone resting upon massive masonry.

The other frigate-dock, the three locks, and the revetment of the basin were built upon piles and a framework of timber, and their masonry was the same as that above mentioned. Lastly, the angles of the recesses for the gates were built with granite.

For the demolition of the whole of these, a division was made between the English and French Engineers in this way—

To the English Engineers—The 3 docks for line-of-battle ships, with half of the revetment of the basin.

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* Under the centre of the floor of the Western Dock, constructed in the bottom of the ravine of Karabelnaia, there were 5 lines of piles intended to support the vessel under repair, the keel of which rested upon granite blocks placed along the centre of the floor.

To the French Engineers—The other half of this revetment, the 2 frigate-docks, and the three locks.

For the purpose of rendering the demolition as complete as possible, and ruining the piles upon which great part of the masonry rested, it was necessary to lodge the charges as low as the water permitted, the chambers being placed only a few inches above its level.

In places where the water did not prevent it, galleries were formed which entered directly into the masonry at the bottom of the walls. This was done in the two docks and the great basin, which were quite dry, and also in the upper lock, the concave floor of which was visible at the bottom of the walls—the latter point was 2 ft. 8 inches above the level of the water, the depth of which at the centre of the floor did not exceed 2 ft. 2 inches.[*]

But in the centre and lower locks, the floors of which were covered by the sea to a depth of 12 ft. 2 in. and 22 ft. 6 in. respectively, it was necessary to form shafts outside the walls in order to reach the chambers for the charges, which were placed about 4 inches above the level of the sea.

CALCULATION OF CHARGES.

By excavating the galleries information was obtained relative to the nature of the masonry, which consisted of a face of cut stone 2 ft. to 2 ft. 4 inches thick, covering masonry formed of large blocks of rubble. The labour of constructing these galleries was often as great and as tedious as if they had been formed in the solid rock adjacent to the Western Dock.

It was considered that for this kind of masonry it would be proper to employ the co-efficient 4 in calculating the charges.

It was by the formula $4h^3$[†] that the charges for the two docks were calculated, with the exception of the mine placed at the curved end of each, for which, on account of their long lines of least resistance (20′ 8″) it was considered that the co-efficient 3·5 should be used.

The formula $4h^3$ was also given up in calculating the charges for the sides of the upper lock, which were determined according to the considerations mentioned further on.

But for the other charges of the locks, as well as for those of the basin, the same formula ($4h^3$) was made use of; and with the object of extending the effect below the level of these mines, the charges obtained by the calculation were increased $\frac{1}{4}$ to $\frac{1}{3}$.

The plate shews the positions of the 181 mines, which were arranged[‡] so that the shafts and galleries would give access to all.

The sketch No. 3[§] shews the general effect produced by the explosions.

DETAILS OF THE CHARGES.

DOCKS.—The two docks were exactly similar in form and dimensions, their foundations alone differing essentially. The Western Dock which is situated on the rock out of which it has been partly excavated, had, according to the Russian plans, a floor about 9′ 10″ thick of solid masonry, covered with blocks of cut stone 2′ 4″ deep.

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[*] The dimensions and weights have been reduced to English measures.—ED.

[†] h represents the length of the line of least resistance in mètres, and the result obtained is the charge in kilogrammes.

[‡] The loss of the 4 chambers of shafts Nos. 3 and 4, destroyed before they were loaded by the explosion of the charges in shafts Nos. 1 and 2, and that of the two chambers annihilated by the cut made in the sill of the upper gate of the highest lock, reduced the number to 171 mines actually loaded, all of which exploded.

[§] It has not been considered necessary to print this plan of the masses of rubbish.—ED.

The Eastern Dock, which is built on piles, had a floor of the same description, but its thickness, above the timber foundation, was only, (according to the same plans), 8′ 3″ to 9 ft.

The principal dimensions of these docks were, in round numbers:—

Length at the surface of the floor.		196′ 0″
Width.	between the two lowest steps.	39′ 8″
	at the upper part.	80′ 0″
Height of the revetment above the floor.		26′ 4″

Mines for Destroying the Two Docks for Frigates.

1. **Mines at the Sides.**—On account of the peculiar form of the profile of the revetments of the docks, the mines at the sides were formed in the masonry, and the charges were placed in the vertical plane which contained its centre of gravity, and as low down as the water permitted, viz.—

In the Western Dock 7′ 3″ below the level of the floor.
In the Eastern Dock 5′ 7″ do. do. do.

Therefore the line of least resistance of these mines, (measured to the plane containing the reentering angles of the steps) was on an average 13 ft. 1 in., and, by placing them at intervals equal to twice the length of that line, only 6 mines were required for each side, making a total of 24 for the two docks.

Their charge, calculated by the formula $4h^3$, was fixed at 551 lbs.

The tamping consisted partly of sandbags, and partly of small rubbish arising from the excavation ; and, in order to increase its resistance, two shields of wood, 6 inches thick, were fixed in grooves formed at the sides of these galleries. The tamping of all the other galleries was executed in the same way and with the same care.

2. **Mines at the Curved Ends.**—In order to ruin all the rounded part with as little labour as possible, the extent of which, between the extreme charges of the sides, was 98 feet, a single charge was placed directly under the centre of the landing, so as to have a line of least resistance towards the landing and towards the surface of the staircase. The line of least resistance was thus 20′ 8″, and the charge, calculated with the co-efficient 3·5, on account of its great length, was 2,206 lbs. To reach these mines the culverts for emptying the docks were taken advantage of.

3. **Mines in the Floors of the Docks.**—As the mines in the revetments could only ruin the edges of the floors, nine shafts were sunk along the centres of each, spread over a length of 184 feet, and at the bottom of each a short gallery was formed for lodging the charges. The thickness of masonry remaining above the roofs of these galleries being, on an average, only 4 feet, the charges were limited to 110 lbs. each.

To prevent the tamping of these shafts being blown out, the chambers were excavated at the sides of the galleries, and the whole of the tamping was composed of timber of large scantling, the interstices of which were filled with earth.

4. **Mines in the Floors of the Entrances of the Docks.**—In order to destroy the floors of the entrances, upon which a large and strong framework rested, forming a kind of sill, seven charges were arranged in the masonry of those floors, and were placed at the ends of galleries leading from the bottoms of three small shafts excavated on the outside of each. The lines of least resistance were 7′ 11″ long, and as these charges were intended to destroy the framework of the sills, the timbers of which were connected by very strong iron spikes, and were 16 to 24 inches square, they were loaded with 176 lbs. each, the effect of which was rendered more certain by tamping both the shafts and galleries with stout pieces of timber.

5. Mines near the Recesses for the Gates of the Docks.—These mines, which were 12 in number, (three at each recess) had lines of least resistance of 10 to 13 feet. In order to reach them the culverts for bringing water into the docks were made use of. Those charges which were nearest to the docks were required to be large enough to make their craters unite with those in the docks themselves which were next to them. (See mines Nos. 5 and 4, 11 and 12.)

The mines (Nos. 6.5, 10 and 11) at the extremities of these portions were loaded with 551 lbs. of powder, but Nos. 5 b. and 10 b. at the centres contained only 441 lbs.—The charges were calculated by the formula $4h^3$.—The culverts were tamped.

Locks.

The three locks were exactly similar.* The walls at the recesses for the gates were 10 to 13 feet thick, but they had no counterforts. The walls of the sides of the locks, on the contrary, were strengthened by counterforts, 6½ feet thick, placed 18 feet from centre to centre, and there were 10 of them on each side.

The difference of level between the floors of the adjacent locks was 10 ft. 2 in., and the same difference existed between the levels of the copings, the height of the walls being 32 ft. 2 in. in all of them.

On the Russian plans the wooden framework of the foundations of the locks is shown 4 ft. 7 in. below the central part of the surface of the floors, therefore this framework was only 7 ft. 10 in. below the centres of the charges in the upper lock.

Mines for Destroying the Three Locks.

1. Mines in the Upper Lock.—As time pressed, only 8 charges were placed in each side of this lock. The two at the ends were lodged near the recesses for the gates, and the six others were distributed as shown in the Plate, without regard to the counterforts. These mines extending over a space of 199 feet, the mean interval was 28 feet 5 inches.

Being placed against the interior surface of the wall, their L.L.R. was only 8 ft. 10 in. If then their charges had been proportionate to this length alone, masses of wall 10½ feet wide would have been left standing between them; and as the counterforts had not been taken into consideration it became necessary to make their craters intersect each other about ⅙th, which gave a radius for the craters of 16½ feet, from which the charges were calculated, employing however only the co-efficient 1.5.

The charge thus calculated was.	413 lbs.
to which ⅓rd was added, to increase the effect upon the floor of the lock, under which no charges could be placed on account of the water	138 "
which gave the total charge for each.	551 lbs.

2. Mines in the Floor of the Entrance of the Upper Lock.—This floor, which was the only one not covered by the water, was 8 ft. 2 in. above the surface of the sea, 11 charges of powder were to have been placed in it, but, on account of the cut which it was necessary to make to allow the water to run off from the upper portions of the docks, only 9 mines were preserved. Their charges were all the same as those in the floors of the docks, viz. 176 lbs, and they were arranged in a similar manner.

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* Contrary to the information afforded by the Russian plans, the inner faces of the walls of the two lower locks were found to be vertical.

3. Mines at the Recesses for the Two Gates of the Upper Lock.—For the 4 mines at the recesses of the upper gate, placed similarly to those at the gates of the docks, the charges employed were larger by 110 lbs. than those of the latter, because the explosion of the latter, which took place before the former were fired, had already produced large cracks in the earth at the back of the recesses, and an escape of the gas through these openings was to be expected, which indeed was actually visible when the charges were fired.

As regards the lower gate, it was necessary, on account of the water which covered the sill, to keep the centres of the 4 mines, intended to destroy the walls of the recesses, about 3 ft. 3 in. above the sill. In order, however, to render the floor useless, each mine was loaded with 662 lbs. of powder, which formed a surcharge of about $\frac{3}{5}$, their lines of least resistance being $10\frac{1}{2}$ feet long.

4. Mines of the Central and Lower Locks.—The centres of the charges of these mines were placed 1 ft. 4 in. above the level of the water, which was met with everywhere; and as the difference of level of the earth outside corresponded to that of the floor, the centres of the charges for the central lock were very nearly 23 feet below the surface of the ground, and those of the lower lock were 13 feet below it.

One charge was placed in each of the 20 counterforts of the walls, and as the walls of the recesses of the two lowest gates had no counterforts, their charges were placed in the masonry.

As regards the charges employed, it was considered necessary to increase the amount obtained from the formula $4h^3$ by about $\frac{1}{4}$th, because it was required to produce an effect at a lower level upon that part of the wall covered by the water to the depth, in the central lock, of $7\frac{1}{2}$ feet, and in the lower one, of 17 ft. 9 in. As these charges were obliged to be placed above the level of the water, it was impossible that they could destroy the *floors.**

The lines of least resistance of the charges lodged in the counterforts were 8 in. 10 ft. long, which was nearly half the distance between the counterforts. The charge $(C + \frac{1}{4} C)$ was 221 lbs.

As an experiment, the mines on the west side of the lower lock were loaded with 265 lbs. each.

The line of least resistance of each mine at the walls of the recesses was 10 ft. 2 in., corresponding to an ordinary charge of 379 lbs.; but, in order to produce an effect upon the wall below the charges, the mines of the lowest gate but one were loaded with 441 lbs. Only 331 lbs. were lodged in each of the mines of the lowest gate on the side next to the sea, the masonry of the recesses having been already shaken by the 1,760 lbs. of powder placed on the floor. (See Note 4 at the end.)

Mines for the Demolition of the Revetment of the Great Basin.

This wall, half of which was demolished by the English and half by us, was of the following dimensions. Its total length was 210 feet, its height was 29 ft. 2 in., and its thickness at the bottom was 7 ft. 10 in. It had counterforts 6 ft. 7 in. thick, and placed 21 ft. 8 in. apart. According to the Russian plans, this wall was built upon piles, but the muddy nature of the bottom of the basin prevented our verifying this. The wall on the west side was partly backed by rock. At about 9 ft. 10 in. in rear of the eastern wall was the great drain by which the water from the docks for line-of-battle ships was carried off.

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* See Note 4, at the end, relative to the experiments made on firing charges under water, with the view of destroying the floors of these two locks.

A mine was formed in each of the 16 counterforts; but the charges were not all equal, although the lines of least resistance were all 9 ft. 2 in. long, for which length the ordinary charge, obtained from the formula 4 h^3, is 194 lbs.

For five mines on the east side only 176 lbs. were employed, and, judging from their effect, this charge must be considered as a minimum.

The mines adjoining the re-entering angles received a charge of 221 lbs. each, yet the portions at the angles were only half overturned, the two coping stones remaining in their places.

Lastly, six mines were loaded with 265 lbs. each, with the intention of destroying at the same time the great drain adjacent to them.

Mode of Firing the Charges by Groups.

The great number of mines, of which the general arrangement and object have been described, could not be loaded simultaneously. It was indeed necessary to leave the charges underground for as short a time as possible, to prevent their being injured by the water, the presence of which had already caused great difficulty. Besides we were not quite certain as to the accuracy of the calculation of the charges for the description of masonry, the resistance of which was known only by comparison, more or less exact, and it was therefore desirable to verify these calculations by observing the effect of some explosions made for experiment, as it may be called.

Finally, it was necessary that the system of locks should not be destroyed till the last, because they secured the escape into the sea of the water which filtered through from the southern portion of the docks, to be destroyed by the English, and which had obliged us to cut several drains in the bottom of the central basin, and to form an opening through the sill of the upper gate of the highest lock.

In consequence of these difficulties General Frossard decided that the explosions should be effected in succession, and by groups, so as to destroy, one after the other, the portions mentioned below, viz.,

1st Group.—The Western Dock, (21 mines).

2nd Group.—The Eastern Dock, the floors and recesses for the gates of both docks; also the revetment of the west side of the great basin, (59 mines.)

3rd Group.—The upper lock, the recesses for the gates, and the sill of its upper gate, (33 mines).

4th Group.—Lastly, the two lower locks, and the revetment of the great basin, (62 mines).

The explosions of the 1st group took place on the 22nd December, and their results proved that reliance might be placed upon the first calculations for determining the charges. The explosions of the 2nd group took place on the 31st December; those of the 3rd on the 19th January, and those of the 4th on the 23rd of the same month.

Firing the Charges.

The ordinary hose, with portions of Bickford's fuze attached to it, was employed throughout to ignite the several groups of charges.

As the operations were carried on under the fire of the Russian batteries, the shells from which sometimes exploded in the midst of our works, no attempt could be made to bring all the portions of hose to one centre, as that would have caused a dangerous extension of it. The charges in each shaft or gallery were therefore fired separately. "Sous-officiers," provided with portfires, were posted at each focus of explosion, and on a signal being given by beat of drum, they ignited the Bickford's fuze, the length of which was calculated to allow sufficient time to retreat, *i.e.*, 4 or 5 minutes.

EFFECTS OF THE CHARGES.

DOCKS.—The masses of masonry in the docks were completely overturned by the action of the powder, without flights of stone being produced, and without much noise. Their interior is now filled with the fragments.

In the Western Dock, which was built upon the rock, the greatest effect was produced on the exterior; not a portion of the masonry remained standing; even the rounded portion, the length of which was 33 yards, was entirely destroyed.

In the Eastern Dock, which was built upon piles, the effect of the charges was diminished. The great subsidence of the earth around this dock, amounting to from 3 to 5 feet, proves that the charges acted powerfully downwards upon the piles; besides the mines were only 6½ feet above the latter. It is to these circumstances that we may attribute the result that some masses of wall remained standing, although pushed out of their original position and cracked in every direction.

The floors of the two docks, as well as the sills of the gates, were rendered absolutely useless, and the massive timbers underneath the latter were violently torn out and broken, and their fragments projected to a distance of several yards.

The walls of the recesses and returns* were overturned and lay in great blocks. Some portions of them remained in their places, supported by the iron gates, which were themselves more or less turned over and broken by the explosions.

LOCKS.—Of the three locks nothing remains; the earth on each side, which was supported by their walls, has slipped down, and in their place nothing is to be seen but a large ditch which the sea has partly filled with water.

All the counterforts have been destroyed with the exception of two in the Central Lock, in which no charges had been lodged; even these however are very much cracked. On the west side of the Upper Lock the upper part of the fifth counterfort is visible, cut out however at its base.

Of the three iron gates which remained, the left-hand half of the lower gate of the upper lock is still to be seen, bent and broken; the others have disappeared amongst the ruins. In the two lowest locks the resistance of the water much diminished the effect of the charges on the walls below its level. At the lowest lock the walls were cut off at the level of only 1 yard below the surface of the water. If this obstacle had not existed the sub-vertical effect would have extended to a distance of at least 8 feet 10 inches, the length of the lines of least resistance of the charges.

On comparing the effects of the charges of 265 lbs. each, placed on the left of the lowest lock, with those of 221 lbs. placed on its right, there appears to be very little difference between them. The wall on the left is cut off at a level of 3 ft 3 in. below the level of the water, whilst that on the right is cut off at a height of only 2 ft. 8 in. below it. On the left the base of the sloping mass thrown down is 20 feet wide, and on the right it is 16 feet wide.

On firing the mines of the lowest lock some of the stones were thrown violently out, which was caused principally by the tardy explosion of several charges, and probably also by the reaction of the great body of water contained in the lock.

GREAT BASIN.—The revetments of the basin were merely overturned. The counterforts in which the charges had been lodged were entirely demolished. The earth in rear of these walls was broken up into great masses which lay in a sloping position. At the re-entering angles, the two coping stones remained in their places, as if to define the extent of the basin and the height of its wall.

CONCLUSION.—The different results above described shew that there was no excess of powder in the charges employed.

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* Of the two walls which supported the ends of the piers between the docks and the upper lock, there only remained the two counterforts, 10 ft. 4 in. thick and 7 ft. 10 in. long, which strengthened those walls in the centre.

TABLE SHEWING THE POSITIONS OF THE MINES AND THE AMOUNT OF EACH CHARGE.

POSITION.	Line of Least Resistance	Charge Calculated at 4 h 3	Charge Employed.	Number of Mines.	Total Number of lbs.	REMARKS.
1. IN THE 2 DOCKS.						
At the curved ends.	20′ 8″	—	2206	2	4,412	Charge calculated from the formula $3{\cdot}5\,h^3$.
At the sides. . .	13′ 1″	551	551	24	13,224	
In the floors. . .	—	—	110	18	1,980	The thickness of masonry above the charges being only 4 feet, the charges were limited to 110 lbs.
At the recesses for the gates. . .	13′ 1″	551	551	4	2,204	These had 3 "lines of explosion," and were loaded in proportion to the longest, which was 13′ 1″.
At the centres of recesses. . .	11′ 10″	413	441	4	1,764	These were increased on account of the resistance caused by the form of the sill.
Near the ends of the recesses next the docks. . .	—	—	551	4	2,204	The result proved that these were rather too weak; the L.L.R. was nearly 15′ 9″.
In the floors at the gates. . . .	—	—	176	14	2,464	The thickness of masonry over these charges was only 6′ 6″.
2. UPPER LOCK.						
At the sides. . .	8′ 10″	—	551	16	8,816	These were equal to $C + \frac{1}{5}C$, the simple charge C being calculated with the co-efficient 1·5, and with the object of obtaining a radius of crater equal to 16′ 5″.
At recess of upper gate. . . .	13′ 1″	551	662	2	1,324	The earth against which these charges were to act having been much cracked by previous explosions, the simple charges were augmented $\frac{1}{5}$ to $\frac{1}{4}$ to compensate for the escape of gas.
In the centre. . .	11′ 10″	413	551	2	1,102	
At recess of lower gate.	11′ 10″	413	662	4	2,648	The "simple charge" was augmented by $\frac{3}{5}$ to produce an effect upon the floor at the gate, which was covered with water, so as to prevent any charges being lodged in it.
In the floor of the upper gate. . .	—	—	176	9	1,584	
To carry forward.				103	43,726	

TABLE SHOWING THE POSITIONS OF THE MINES AND THE AMOUNT OF EACH CHARGE.

POSITIONS OF CHARGES.	Line of Least Resistance.	Simple Charges (lbs.)	Charges Employed.	Number of Charges.	Total Number of Pounds of Powder.	REMARKS.
Brought forward.	..	..	..	103	43,726	
3. CENTRAL AND LOWER LOCKS.						
Sides of two locks.	8′ 10″	174	221	27	5,967	The water in the locks preventing these charges being lodged at the bottom of the walls, the "simple charge" was increased ¼, to destroy the masonry as low down as possible. The resistance and re-action of the water in the locks, against the shock produced by the charges, lessened their effect in a downwards direction. The walls were cut off at a level of only 2′ 8″ above the surface of the water.
LOWER LOCK.						
Charges of the Shafts Nos. 19, 21, 23, 25, 27, 29 and 33	8′ 10″	174	265	11	2,915	This charge of 265lbs. tried as an experiment, produced an effect but little greater than that of 221 lbs. The walls were cut cut off at a level of 3 ft. below the surface of the water.
CENTRAL LOCK.						
Charges of the Shafts Nos. 5 and 6.	8′ 10″	174	331	2	662	These two charges were required to produce such an effect in a horizontal direction as to overturn a mass of wall about 13 feet long, which was to have been done by the mines of the shafts Nos. 3 and 4, destroyed, before being loaded, by the mines at the recesses of the lower gate of the upper lock. The effect desired was obtained.
At the recesses of the lowest gate but one.	10′ 2″	379	441	8	3,528	The same reason existed for the the increase of ⅓rd made to the simple charge as for the above-mentioned charges of 221 lbs., and the result obtained was the same.
At the recesses of the lowest gate.	10′ 2″	379	331	8	2,648	A reduction of the charge to 331 lbs. was made because the recess walls had been shaken by the explosion of 1,764 lbs. placed on the floor (see Note 4 at the end). The thickness of earth above these charges was only 13 ft., whilst that above the preceding charges was 23 feet.
4. CHARGES IN THE WALLS OF THE GREAT BASIN.						
West Side.	9′ 2″	194	176	5	880	From the result this must be considered as a minimum. The wall was overturned.
On each side of the re-entering angles.	9′ 2″	194	221	5	1,105	An addition of ¼th was made, in order to ruin the re-entering angles. These angles were broken down.
East side.	9′ 2″	194	265	6	1,590	The surcharge of these mines was intended to destroy a culvert running at a short distance from them.
Total				176	63,012	

The total amount of masonry destroyed by the above-mentioned 63,000 lbs. of powder is 85,000 cubic yards, viz.:—

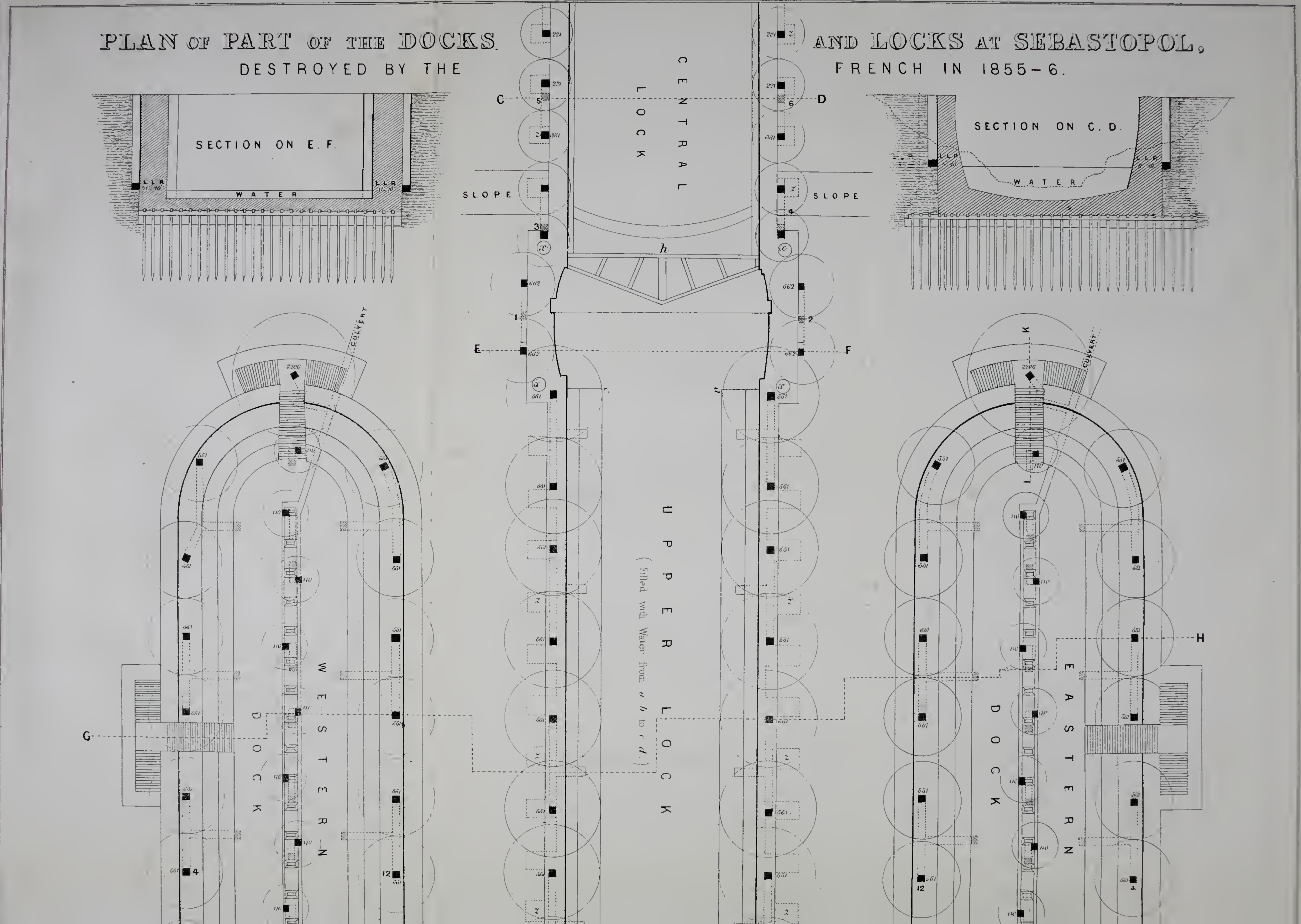
In the two docks.	38,379	cubic yards.
In the three locks.	42,153	,,
Part of the walls of great basin.	4,333	,,

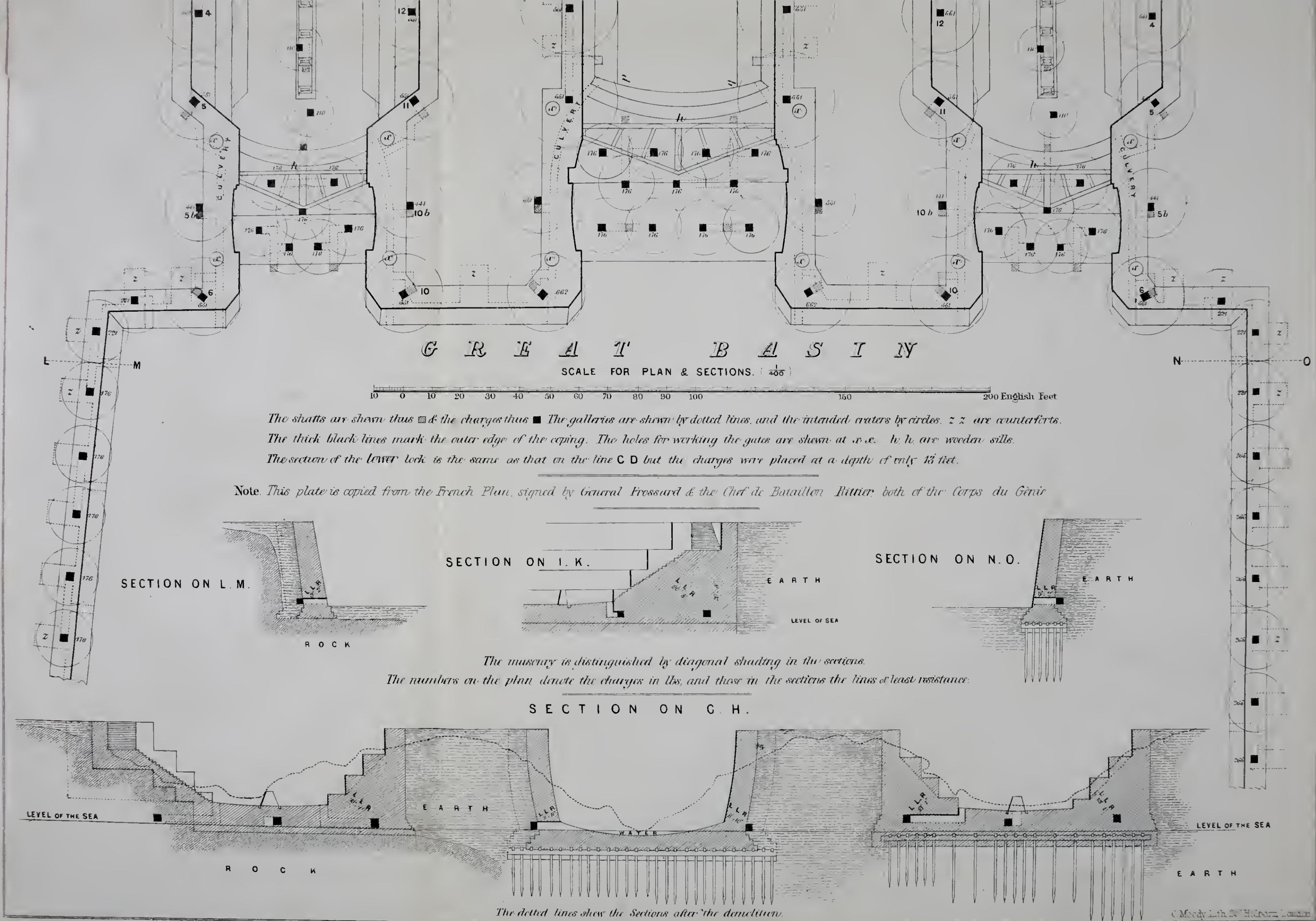
NOTES EXPLANATORY OF THE DETAILS.

Note No. 1.—Table containing details relative to the explosions of the groups of charges.

DATES OF EXPLOSIONS.	Situation of Groups.	Number of Charges.	Number of foci.	Dates of placing the boxes and hose.	Dates of placing the charges.	Tamping completed.	Firing.	No. of lbs. of powder in each explosion.	OBSERVATIONS.
22nd Dec.	Western Dock.	21	14	21st Dec.	Night of 21st Dec.	Morn. of 21st Dec.	1 P.M. 22ndDec.	9,710	Demolition complete and without any projection of stones.
31st Dec.	Eastern Dock, floors and recesses for gates of both docks, Western part of of wall basin.	59	34	28th & 29th December.	Night of 29th Dec.	30thDec.	1 PM. 31st Dec.	20,545	Demolition equally complete. At this explosion there were no stones thrown out, but 4 of the charges did not go off, which arose from the safety fuze, laid on the surface of the ground, being cut by the fragments of stone from the charges which exploded prematurely. They were ignited immediately afterwards and without further labour.
19th Jan.	Upper Lock, recesses for gates, and sill of upper gate.	33	14	18th Jan.	Night of 18th Jan.	Morn. of 19thDec.	1 P.M. 19th Jan.	15,445	In the upper lock all the fuzes of the mines in the western wall were extinguished by the water propelled by the premature explosion of the mines of No. 6 in the eastern wall. It was necessary to open out the entrances to the galleries on the western side, which were covered with the debris, and to refix the hose. They were fired at 1 P.M. next day. The destruction was complete and without any projection of stones.
23rd Jan.	Lower Lock and Eastern wall of the Great Basin.	62	33	commenced Jan. 22nd at 1 P.M.	Night of 22ndJan.	Morn. of 23rd Jan.	1 P.M. 23rd Jan.	17,300	Result complete. In the explosion of the mines of the lower lock, the walls of which were only 14′ 5″ above the level of water, which was 22′ 6″ deep, stones were thrown out with much force to a great distance. The tardy ignition of some of the charges, and also the resistance afforded by the water in the lock, explain these projections of stones.
	Totals..	175	95					63,000	

PLAN OF PART OF THE DOCKS AND LOCKS AT SEBASTOPOL, DESTROYED BY THE FRENCH IN 1855-6.





GREAT BASIN

SCALE FOR PLAN & SECTIONS. ($\frac{1}{400}$)

The shafts are shewn thus ▨ *& the charges thus* ■ *The galleries are shewn by dotted lines, and the intended craters by circles. z z are counterforts.*
The thick black lines mark the outer edge of the coping. The holes for working the gates are shewn at x x. h h are wooden sills.
The section of the lower *lock is the same as that on the line* C D *but the charges were placed at a depth of only 13 feet.*

Note. *This plate is copied from the French Plan, signed by General Frossard & the Chef de Bataillon Rittier, both of the Corps du Génie*

SECTION ON L. M.

SECTION ON I. K.

SECTION ON N. O.

The masonry is distinguished by diagonal shading in the sections.
The numbers on the plan denote the charges in lbs, and those in the sections the lines of least resistance.

SECTION ON G. H.

The dotted lines shew the Sections after the demolition.

C. Moody Lith. 257 Holborn, London

Miscellaneous Notes.

The above-mentioned works were undertaken by the companies of Captains Pornain and Berrier, with the assistance of some men of the Line.

The numbers furnished daily were:—

The two Companies of Engineers . . .	132 workmen.	154
The Auxiliaries of the Line. . . .	22 „	

which allowed of 42 mining attacks being commenced, out of the 102 required to be undertaken, viz.:—

Western Dock.	14	42
Upper Lock.	14	
Eastern Dock.	14	

The works requiring to be pushed on with more activity, the numbers were augmented on the 23rd November by 170 Sappers, furnished by the companies commanded by Captains Chaplain, Maritz and Béziat, as well as by 50 additional men from the Line, raising the total number of the latter to 374; but disease soon reduced it to 300.

For the single attacks 3 men were employed, and for the double attacks 4 or 5 men.

The time occupied in the works was 8 hours of actual labour out of the 24 hours.

During the time when the attacks in arrear required the work to be continued for 24 hours consecutively, brigades were formed which were relieved every 8 hours.

According to notes kept by the officers the mean rate of progress was,

In masonry (per running mètre).	40	hours.
In rock „	70	„
In earth — shafts, with sheeting (per running mètre). .	3	„
In earth — galleries „ „ . .	3	„

From the same notes it appears that for masonry, picks, iron wedges and mallets are most useful; and for rock, the "grain d'orge*," mallet, masons' hammer and crowbar.

Finally the following notes were made relative to the progress of the mining operations:—

Description of Work.	Time Occupied. To complete the mines.	Time Occupied. To place the boxes and hose.	Time Occupied. To carry and lodge the powder.	Time Occupied. Tamping per running metre.	Number of men employed.	Remarks.
For a mine containing 2,206 lbs.	15^{h} 30	6^{h} 30	2^{h} 0	30′	20	The wood for tamping and the sandbags were ready prepared at the entrances of the shafts and galleries. The powder was taken from the artillery magazines as it was wanted. It was brought to the docks early in the night and lodged at once in its place.
T Gallery with mines in the docks	15 0	10 0	„ 50	20′	16	
One in upper lock of 551 lbs. . .	12 0	8 0	„ 50	20′	12	
Charges at the recesses for the gates of 551 and 662 lbs.	18 0	10 0	1 30	25′	15	
Charges in the floors of 110 lbs.	4 0	2 0	„ 12	20′	4	
Shafts in central lock 24′ 4″ deep, with charges of 221 to 441 lbs. .	7 50	2 40	„ 40	38′	6	
Shafts in lower lock 14′ 1′ deep, with charges of 221 to 441 lbs. .	4 2	2 10	„ 36	38′	6	

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* This is a kind of chisel or punch.—Ed.

This work, so laborious to the miners, was done by tasks.

The excavation of masonry was paid for at the rate of 2 fr. 75c. per running mètre, and that of rock at 3 fr. 75 c.

For other work they received during the day 5c. per hour, and during the night 10c.

Note No. 2.—On Firing the Mines.

The safety fuze employed (called No. 1) had been for some time kept in huts open to the weather, and had lost its property of burning uniformly at the usual rate of 1 mètre in 95 seconds. This deterioration of the fuze was the principal cause of the delays in the transmission of the fire to the charges, but the want of simultaneous action of some of them was not prejudicial to the general effect, which was complete:

Note No. 3.—Execution of the Work.

The construction of the different shafts and galleries above-described was commenced on the 27th October, and on the 21st December everything was ready for the loading.

The works were however delayed by the water, which penetrated into them several times: on the 13th December, especially, the galleries in the docks, and at the recesses for the gates, were flooded in consequence of the heavy rains of the preceding days. Thus very laborious pumping became necessary, which required to be continued even after the excavations were resumed.

In order to get rid of the water retained in the great basin by the sill of the upper lock, a cut was made in it, thus sacrificing two of the mines formed there; and several ditches were excavated in the bottom of the basin, so as to lead the water to this cut. These works drained the basin, and thus the water in the galleries was diminished; but it was still necessary to secure them, as well as the chambers for the powder, against the rain water which, after falling on the surface of the ground, found its way through fissures in the rock, and filtered through the masonry. For this purpose the crevices in the shafts and galleries were filled with hydraulic mortar, made with puzzolana and lime found on the spot; and a coat of the same was also laid on over all. Finally the bottoms of the shafts and of several of the galleries were covered with layers of bèton.

It was not till after the completion of these precautionary labours that the loading of the mines could be proceeded with, and in order to prevent the risk of failure, the hose, hose-troughs and powder cases were covered with a mixture consisting of two parts of chalk and one of tar. The cases for the powder were also raised as high as possible above the floors of the chambers, by means of wedges, and the hose-troughs were attached to the roofs of the galleries by means of iron spikes.

Note No. 4.—Explosions Under Water.

As it was desired, before destroying the two lower locks, to make some experiments on exploding powder under water, four charges were lowered down on to their floors; these were enclosed in iron cases and were fired by electricity.* A charge of 132 lbs. was first placed on the centre of the floor of the central lock, where the water was 12 ft. 4 in. deep. After the explosion, it appeared, on sounding, that a depression of only 2 feet had been produced in the floor.

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* The details of these experiments were collected in a special note written by Captain Guillemot.

A similar charge was placed on the centre of the floor of the lowest lock, where the depth of water was 22 ft. 5 in. The effect produced by this was the formation of a hollow in the floor 2 ft. 8 in. deep.

The two results having proved the insufficiency of the charges employed, a charge of 662 lbs. was placed on the sill of the lowest gate but one, which was covered with water 12 ft. 4 in. deep. The effect of this was very great: the sounding-rod penetrated to a depth of 5 ft. 5 in. below the surface of the floor, and as, according to the Russian plans, the foundation, formed of a framework of wood, is only about 4 ft. 7 in. below the centre of the floor, we may conclude that the piles have suffered considerably from this explosion. No injury appeared to have been sustained by the walls of the recesses for the gates. A beautiful column of water was driven up to a great height.

A 4th charge, of 1,764 lbs. was placed on the sill of the lowest gate, having over it a body of water 22 ft. 5 in. deep. A considerable movement took place in the water. After being dashed about in all directions, an enormous white column of water was thrown up, and almost immediately afterwards the violent re-action projected another column into the air; but this was black, and appeared to be crowned, as it were, by the white one. The whole appeared for an instant to assume the form of a magnificent plume of feathers, which disappeared as it fell back into the sea. The radius of rupture below the level of the floor, as shewn by sounding, reached the length of 8 ft. 2 in.; the piles beneath it must therefore have been destroyed. The masonry of the recesses of the gates opened longitudinally to a distance of 12 to 16 inches, and separated about 4 inches from the earth behind.

Although these experiments were not complete they nevertheless added some useful information to what had been previously obtained relative to explosions of powder under water.

We may conclude, for example, from the effect produced by the charge of 1,764 lbs, that if the 15,744 lbs, by means of which only the demolition of the walls of the two lowest locks had been obtained, had been divided into several charges and placed on their floors, not only the walls, but also the floors of those locks, would have been entirely destroyed.

Sébastopol le 26 Février 1856.

Le chef de bataillon du génie,

(signé) Rittier.

Pour copie conforme.

Sébastopol 9 Mars 1856.

Leg. commandant provisoir. le génie de l'armée,

Ch. Frossard.

PAPER VI.

NOTES ON THE CONSTRUCTION OF THE DEFENCES OF KARS.

By COLONEL ATWELL LAKE, C.B., late of the Madras Engineers.

As considerable interest has been excited among military men, more especially among officers of the Engineers, both in the Royal and Indian Armies, with regard to the blockade of Kars by the Russians under General Mouravieff in 1855, the following remarks (thrown hastily together) on the nature of this ancient fortress, which is said to have existed since the year 1589, and on the measures which were taken, under the orders of General Sir Fenwick Williams, Bart., K.C.B., H.M. Commissioner with the Ottoman Army in Asia Minor, for adding to and strengthening the defences, may not be altogether unacceptable to those who are not unwilling to gain some information, however slight, from the experience of their brother officers.

The town of Kars is situated in Armenia (43° 16′ E. Long., and 40° 15′ N. Lat.) having a vast plain in front, and high mountains in rear. The chief habitations are within the walls of the fortress, but there are also suburbs outside, the principal one of which is partly surrounded by a wall of defence, built in rough stone, with two small bastions at the east and west angles. The fortress itself is in the form of an irregular polygon, the northern face resting on the steep rocks which form the right bank of the river Kars-tchai. There is a double "enceinte" of walls, built of blocks of stone in cement: on the outer wall, which forms altogether a circuit of 2,600 yards, are four tolerably large bastions, and the inner wall is flanked by numerous small round and square towers, placed at various distances from each other. At the north-west angle is situated the citadel, considerably raised above the plane of the fortress: this is, in itself, a strong place, but would become untenable as soon as an enemy should succeed in establishing himself on the hills, on the other side of the river, which completely command it.

To the eastward of, and commanding the fortress, stands the Kâradâgh mountain, which was in 1828-29 fortified by a battery of earth, well armed with cannon.

There was also a tower, now in ruins, called the Castle of Temir Pasha, situated on the opposite bank of the river, to the westward of the fortress, which evidently was intended to serve as a defence for part of the town.

This imperfect sketch will perhaps serve to show the nature of the works as they stood when the place was attacked and taken by Prince Paskievitch's army in the year above-named.

It will now be necessary to describe briefly the state of the defences as they were found to exist when the snow disappeared in April 1855.

The fortress itself remained much in the same state as it was in 1829—time had not done much damage to the solid masonry of which the walls were built; and about as little good had Turkish skill effected in adding strength to the position by the construction of earthworks. Not one single redoubt, properly so called, had been thrown up, nor had sufficient precautions been taken for the defence of the hills.

It is somewhat difficult to describe the exact nature of the works which had been raised without showing a plan of them as they existed.

It had been considered expedient, in order to prevent an enemy from coming suddenly too close to the fortress, which itself presented no great obstacle if regularly besieged, to surround a portion of the place with an entrenched line, commencing it at some distance from the foot of the Kâradâgh mountains on the east side, and carrying it as far as the Erzeroom road on the west. Owing to the nature of the ground, which rises considerably from the town to the plain in front for some distance, and then immediately falls, it was found necessary to trace the line a long way off, which made it very extensive and consequently inconvenient, if, as afterwards proved to be the case, the position had to be held by a limited garrison. This breastwork, partly from being damaged by remaining under the snow all the winter, and partly (it might almost be said chiefly) from having been constructed on totally erroneous principles, presented a ridiculous appearance when it became visible. In several places there were great gaps many hundred feet in length, and in no place was the line sufficiently high to prevent a pony from jumping over it—it afforded no cover whatever for the men, having neither banquette nor trench in rear, and little or no ditch in front, the earth of which it was composed having been brought from a distance; it was formed on no particular profile; it had been discontinued between the Erzeroum road and the river on one side, and for nearly the same distance from the foot of the mountains on the other; the openings or passages through it, of which there were an unnecessary number, were left unprotected, and flanking fire seemed to be a thing wholly unknown, or at all events disregarded.

At the eastern extremity of the south line of breastwork, three sides of a large rectangular redoubt had been constructed, called Hâfiz Pasha Tabia (the word 'tabia' signifying a battery) (marked in the Plan No. 1); not only had it been left open and undefended at the gorge, but it had insufficient parapets and no magazine.

At the other extremity of the line stood a small irregularly shaped battery called Kanli Tabia (marked No. 22) with the same defects as the one just described, being altogether a most useless work as it then stood.

Between these two batteries, and on the same line of breastwork, two small lunettes, of a better construction, called Feyzi Bêy and Yeni Tabias (marked respectively Nos. 23 and 24) had been thrown up, but neither of them were closed at the gorge, nor were they provided with magazines. The breastwork connecting these two works had been raised and strengthened by Major Teesdale on his first arrival at Kars with General Williams, in October 1854, but it had been much injured during the winter by the snow which covered it.

On the western line, facing the Erzeroom Road, part of the breastwork had been put into a tolerable state of repair, and salients thrown out so as to convert a portion of it into an open battery for guns "en barbette" called Suwarri Tabia (No. 21).

On the eastern side, nearly at the foot of the Kâradâgh Mountains, on a badly chosen site, a small battery called Koltuk Tabia (marked No. 2) had been erected, intended to command the Alexandropol Road, and to sweep the eastern line of breastwork.

These fortifications, together with the dilapidated remains of the wall which originally surrounded the principal suburb, and the two batteries at the angles, called

Yussuf Pasha and Chicheck Tabias (marked Nos. 26 and 27) constituted the whole of the lower works of defence.

The Kâradâgh Mountains were fortified by long straggling open works, difficult to describe, with one small redoubt on the highest point, the whole of which were very much out of repair.

To the N. N. West of this position, on an eminence very little lower than the Kâradâgh, and close upon the right bank of the river, a large and not altogether badly planned redoubt, called Arab Tabia (marked No. 4) had been constructed; but, like all the others, it was incomplete, being open at the gorge, and having low and weak parapets.

The fortifications on the opposite or northern side of the river, where the mountains entirely command the fortress and town, consisted but of few works, and they were indifferently planned, with the exception of one small open battery (No. 5) situated on the edge of the precipice overhanging the river, and commanded by Arab Tabia. It had been constructed in the preceding year by Major Teesdale, and afterwards bore his name. Two of the remaining works were small lunettes (Nos. 6 and 7) called Thompson and Zohrab Tabias, open at the gorge and very injudiciously placed, as an enemy could, from the nature of the ground, approach almost close to them without being perceived. These three detached works occupied a ridge nearly parallel to the river. The most commanding spot of all, and indeed the key of the whole position, was to the north west of the fortress; on it was constructed a work perfectly open in the rear, called Vêli Pasha Tabia, afterwards " Fort Lake" (No. 10) consisting of an irregular line of parapet, pierced with embrasures built in stone and cement, while the remainder of the work was of earth—its site was well chosen, but it would have been difficult to have made a mistake in this respect, as the necessity for a work on this spot was too palpable to be easily overlooked.

There was one other work called Tchim Tabia, afterwards " Vassif Pasha Tabia" (No. 19) well placed on rising ground commanding the river to the west of the town —the work itself was small, being in the form of a double Redan, or "tête à queue d'hironde," and was capable of holding two guns.

These were all the works which formed the defences of Kars in April 1855, and not only were they faulty and imperfect in form, but they were all, more or less, in a dilapidated state.

Lieut.-Colonel Atwell Lake of the Madras Engineers, attached to the staff of H. M. Commissioner, had proceeded to Kars with full powers from General Williams and the Mushir (Marshal) commanding the army, to remodel the existing fortifications, and to construct such new works as he might consider necessary for the safety of the place. Instructions were also sent to the Commandant at Kars to attend to any requisition which he might make for working parties.

It must be remarked, before proceeding further, that no such body of men as an organized Corps of Engineers exists in the Turkish Army; it is not to be wondered at, therefore, that the notions which the Turks had of fortifications were somewhat crude, and their ignorance of the way in which field works are thrown up was very great. It is true that a small number of soldiers, about 50, selected at random, had been detached from their regiments and placed under an officer possessing a certain amount of intelligence, named Major Hadji Agha, for the purpose of being taught to work at the defences; but the progress they had made was very inconsiderable.

Lieut.-Colonel Lake at once applied for 80 men to be taken from the ranks on the recommendation of their commanding officers, and to be placed under the orders of Hadji Agha for the purpose of learning how to make gabions, fascines, &c., and to prepare profiles for the works about to be constructed. These men attended daily at the quarters of Lieut.-Colonel Lake, and in a very short time turned out gabions worthy of trained Sappers : the want of wood, however, soon put a stop to this work, and their labour was afterwards chiefly confined to cutting and preparing profiles, and laying down wooden platforms in the batteries.

On the 10th of April 500 men were, as a preliminary step, set to work on the entrenched line, under the superintendence of Major General Hafiz Pasha, the only officer in the garrison who professed to have even the slightest knowledge of engineering.

It may be here remarked that this officer laboured, without ceasing, throughout the whole affair, at the duty he had undertaken, and he well deserves the acknowledgments of the Engineer officer, to whom he proved himself so able an assistant.

There were so few entrenching tools, they were so inferior, and the men were so awkward, from never having been accustomed to handle them, that any attempt to get the work done seemed, at first, almost hopeless. After a time, however, the men seemed to take an interest in their occupation, and not only did they labour cheerfully, but they performed their tasks in a most satisfactory manner.

As it might reasonably be expected that the Russians, if they intended to attack Kars, would advance as soon as the weather became sufficiently open, it was of great consequence to get the works as forward as possible : to effect this object it was found desirable to commence several batteries and entrenched lines at the same time, employing on each a certain number of companies from different battalions, giving them task work, with the understanding that as soon as the portion allotted to one battalion was finished the men belonging to it had permission to leave off work. It was astonishing to see the good effects of this rivalry, and the pride and delight with which a body of men would announce the completion of their task. Lieut.-General Kherim Pasha, at that time commanding in Kars, might be seen every day at the several works in progress, smoking his pipe and encouraging the men to exert themselves.

In some places an entirely new line of breastwork was marked out, and the rest was put into a thorough state of repair, affording good and sufficient cover for the men, the profile varying of course with the nature of the ground. The necessary precautions were taken for protecting the openings for the ingress and egress of troops, and for the public roads which necessarily pass through the lines.

The several batteries below were strengthened, added to, and altered where required ; they were all closed at the gorges, and provided with proper magazines. " Chevaux de frize" were made up by the Sappers, and each battery was supplied with as many as were required ; various small works, as shewn in the plan, were also added for the purpose of giving the necessary flanking fire, so that, after a short time, the lower works assumed a tolerably defensible appearance.

A small 3-gun battery called " Bogas Tabia," was also erected in a commanding position at a bend in the river, not far from the town, affording a very considerable range for the guns. Koltuk Tabia was entirely demolished, and a new one, on a larger scale, was constructed higher up the slope of the Kâradâgh Mountains, on a much more commanding site.

It was evident to the Engineer officer, and even to an unprofessional eye, that so long as the mountains to the north-west of the town remained insufficiently fortified, the place would be perfectly untenable for any length of time. It must not be supposed therefore that, while the works just described were under execution on the plain below, the upper defences were neglected.

On the spot where Tchim Tabia stood, a large enclosed redoubt, which afterwards bore the name of the Mushir, Vassif Pacha, was constructed, having the command not only of the river for a considerable distance, but of a great part of the town and of the permanent stone bridges; two large magazines were placed under the traverses, and the whole work was made as complete as possible.

It may, perhaps, be as well to make some allusion to the manner in which the batteries and breastworks were thrown up, and as there was but little difference in their construction, one description will suffice for all.

As soon as the site for a battery had been fixed upon by the Engineer officer, he at once marked out the shape with tent pegs and ropes, placing small stones to denote the lines, as it frequently happened that the nature of the soil was so hard as to render it impossible to mark them with a pick-axe. A small party of sappers with their tools and a few thin planks were quickly on the spot, and one profile having been cut and nailed together under the superintendence of the Engineer officer, a number were at once made and put up. Working parties having been sent for, and told off to their respective tasks, piled up large loose blocks of stone, which were found lying all over the place in great abundance, until they assumed nearly the shape of the profiles, only on a reduced scale—the ditch was then excavated and the earth thrown up and well beaten down, preserving the exact section required. While this was going on, a working party was employed in cutting turf, with which the entire surface of the battery or breastwork was neatly covered. The principal difficulty to be contended against was the hard and rocky nature of the soil, particularly on the mountains, which rendered it almost impossible to excavate a ditch of proper dimensions—in some places, indeed, it was found necessary to form a ditch by raising the counterscarp and making a small glacis. In the manner described were all the batteries constructed, and not only did the parapets possess considerable strength and solidity, but the whole work presented an appearance of great neatness and regularity.

On the site of Vêli Pasha Tabia, taking in the greater portion of the existing work to form part of the new one, a large and very formidable redoubt was built, capable of containing a garrison of three thousand men. Magazines were made, and a very large wooden block-house of enormous strength, capable of holding three hundred men, was constructed at the gorge. It was built like most of the dwelling places found in Turkish and Armenian villages—of large trees roughly trimmed and laid one on the other, dove-tailed into each other at the angles, the roof being formed in like manner—it was then thickly revetted with earth, and turfed all over so as to render it completely shot-proof; it was of course loop-holed all round, and the interior was fitted up in such a manner that raised planks running the whole way round served for sleeping places as well as for a banquette. This block-house was constructed under the superintendence of a foreign officer, named Vêli Effendi, attached to the department of the chief of the staff, and its execution reflected great credit on the skill and energy which he displayed. The redoubt when finished received from the Turks the name of "Fort Lake" (No. 10).

The two lunettes before alluded to (Nos. 6 and 7) situated on the heights, were raised, strengthened, and closed at the gorges, the same necessary precautions were also taken with the small work (No. 5) called Teesdale Tabia, the whole forming what was called the "Line of English Batteries."

The works on Kâradâgh were considerably added to and strengthened. Arab Tabia (No. 4) was also put into a state of repair, and, being too large for any garrison likely to be spared for it, rather than incur the trouble of reducing its dimensions, it was considered advisable to construct a reduit in the centre, commanding the whole of the original work.

The bulk of the ammunition had, up to the time now arrived at, been kept in the citadel in a most insecure place, and no precautions whatever had been taken to guard against accidents. One of the already existing buildings in the citadel was, therefore, converted into a main magazine by re-roofing it, erecting a traverse wall, and rendering the place bomb-proof.

About seven weeks were spent in completing the fortifications and other works thus detailed, and nothing could possibly exceed the willing, cheerful, and expert manner in which the Turkish soldiers worked, wholly unaccustomed as they had before been to any labour of the kind. It would have been most desirable (and, had time permitted, it was fully the intention of the Engineer officer to have done so) to alter the position of the two lunettes composing part of the line of "English Batteries," for the defect in the site of these works, as before described, was very great. Still there were so many more important things to be attended to that it was not considered advisable to do more than strengthen their parapets and close their gorges.

Two temporary bridges were thrown across the river in order to facilitate the communication between the lower works and those on the heights, and thereby avoid having to make a détour by the stone bridge situated further down. They were constructed of wooden pontoons, which had been used for the same purpose during the preceding year, and were of a very clumsy description, not being even well adapted for such stationary service, still less for transport in the event of the army having to take the field.

On the 7th of June General Williams arrived in Kars from Erzeroom; he minutely inspected all that had been done to the fortifications and expressed himself satisfied with the several arrangements that had been made. Although much had been accomplished towards putting the place in a defensible state, a great deal still remained to be done: more might doubtless have been effected had time allowed, and had the Engineer officer been provided with means and adequate assistance, in both of which, as before stated, he was very deficient.

It has been shown that the position on the hills commanding the town and fortress on the north side had been made tolerably strong by the construction of "Fort Lake" and the "English Batteries," but it could not be considered safe so long as it remained, in its turn, commanded by another range of hills lying to the westward at a distance of about 1,900 yards. The necessity of fortifying these heights was too apparent to be overlooked, and though it would increase the defences to a most inconvenient extent, taking into consideration the numerical weakness of the garrison, still there appeared no help for it.

General Williams having carefully gone over the ground in company with Lieut.-Colonel Lake, directed that open works should be constructed of such a nature that they might serve to protect the approaches to the hills, and at the same time prove useless to the assailants in the possible event of the besieged having to retire. This was accordingly done by throwing up a line of breastwork capable of containing two field batteries "en barbette" protected by a few companies of Chasseurs. A similar work called Lâz Tabia (No. 11), was also constructed on rising ground betwen "Tachmasb" and "Fort Lake," intended for a like purpose. At the same time a road was marked out and roughly made to render the communication easy between these new works and the more permanent defences.

While all this was in progress other works were being carried on in different parts of the position. The batteries of Kâradâgh and the "Arab Tabia" were connected by a breastwork, in order to protect the valley, formed by the hills on which they stand, from a sudden attack. A similar work was also thrown up, uniting the English batteries with each other and the whole line with "Fort Lake," taking advantage of some rising ground on which a semi-circular open battery, called "Churchill Tabia," (No. 8) capable of holding three light guns, was erected.

All the troops in garrison, except those on duty, were thus kept constantly employed, and nothing could exceed the cheerfulness and dexterity with which they worked, each battalion being anxious to show how quickly it could accomplish its task. This constant employment not only tended very materially to keep the troops in health by giving them steady (and at the same time not too severe) exercise, but as they saw the various works gradually rising up, they also became inspired with greater confidence in their means of defence against the superior force encamped before them.

From the moment the enemy appeared in front of Kars, and indeed for some time previously, no further supply of wood adapted for gabions and fascines could be procured, and the number of these most necessary articles was very inadequate to the demand. The few gabions that had been made were distributed among the larger batteries and were placed on the barbettes, five or seven, according to circumstances, on either side of the gun, on the superior slope of the parapet. When filled with earth they afforded very tolerable cover for the men working the guns and gave them great confidence—the plan had this advantage that the gabions could be removed at pleasure in a very short time, no small consideration when the number of them was so limited. In "Fort Lake" the cheeks of the embrasures were protected by basket-work which stood uncommonly well. The fascines were very soon expended in roofing the magazines, and even for this purpose there was a very insufficient quantity.

Many circumstances occurred which induced General Williams to think it by no means improbable that, in the event of an attack, the position of Tachmasb would be the first point to which the enemy would direct his attention, more particularly as he had twice reconnoitred these heights in force. Lieutenant Colonel Lake was, therefore, directed to strengthen the fortifications on this spot, and accordingly the line of breastwork, which has been before alluded to, was extended towards the south. At the point where the two lines formed an angle (marked No. 17 in the Plan) barbettes were thrown up, making, as it were, a kind of open redoubt, and at the extreme end of the line a return was made with two salient angles for light guns to sweep the road running in front of the position.

To the northward of these works, and at a distance of about 450 yards from the open battery just described, it was found necessary to construct a small enclosed redoubt called Yuksek Tabia (marked in the Plan No. 15) as the spot commanded the Tachmasb line. To the southward of this work, at a somewhat lower level, a small open battery, named Yarim Ai Tabia, (No. 16) was thrown up, and to the northward a long line of fortifications, called Sheshanadji lines (No. 14), consisting of a small open battery and breastwork, was erected—they were situated on a ridge of hills commanding the valley leading to the front of the English batteries, and were intended for the purpose of preventing the Tachmasb works being taken in flank. The breastwork alluded to was originally merely a number of small detached parapets thrown up at irregular intervals on the slope of the hill, each one giving cover to about five or six riflemen, but it was subsequently considered safer to unite them so as to form a continued and unbroken line. Still further on towards the north two small salient works with a connecting parapet were constructed, in order to extend the defences of these heights. A very important position, opposite to the village of Tchakmak, and commanding the road leading from the valley to "Fort Lake" was also fortified by an open battery called Tetek Tabia (No. 12).

All these precautionary measures, as it was subsequently proved, were by no means thrown away, and there was not one of these works, thus imperfectly described, which was not, more or less, engaged on the day of assault. While the fortifications on the heights of Tachmasb were in progress many other works were being carried on. In order to facilitate the communication between "Arab Tabia" on the one side, and the

"English Batteries" on the opposite side of the river, and obviate the necessity for troops having to take the circuitous route by the town, a rough stone bridge, consisting of two piers and wing-walls, with a wooden platform, was thrown across the Kars-Tchai just below "Arab Tabia," where the width of the river is about fifty feet, and its depth varies from five to nine feet. Stone was found in great abundance close to the spot, and so expeditiously did the soldiers labour that the whole work was completed in three days. The bridge stood well, and was afterwards of the greatest service on the day of the battle, enabling the officer in command of the Kâradâgh line to send reinforcements over, without delay, to assist in retaking the English batteries when they fell into the hands of the Russians.

Some short time prior to the 29th of September, the day on which the place was attacked, a battery named "Williams Pasha Tabia" (marked No. 9) was constructed on dead ground lying in rear of, and not far removed from the "English Batteries," and close to the precipice over-hanging the river. This spot, being visible neither from the works alluded to, nor from "Fort Lake," it was considered dangerous to leave undefended, particularly as it commanded the fortress and nearly the whole of the town. It was, moreover, intended that this battery should serve as a place of refuge, in the event, as afterwards proved to be the case, of the garrison being driven out of the line in front.

Thus far the works on the heights were completed, and in order to give as much confidence as possible to the garrison, it was thought advisable to form a second or inner line of defence below. This was accordingly done by connecting, by means of a breastwork, the walls of the fortress with the burial ground in front, the enclosures of which, constructed of loose stone well put together, were raised and strengthened; and then carrying on the breastwork again till it joined Chicheck Tabia (No. 27). A line of fortification already existed connecting this last named work with "Yussuf Pasha Tabia" (No. 26), forming part of the original defence of the principal suburb —this line was considerably added to and improved by raising the parapet, turfing the exterior and superior slopes, facing the interior slope with rough stone neatly built up, and making a banquette, none having existed before. The two entrances through this breastwork into the town had been hitherto wholly unprotected—one of them was now closed, and a new one cut through in a more convenient place, throwing out a couple of flêches in front of this and the other opening which was allowed to remain. Barbettes were constructed, where necessary, along the whole line of the new breastwork between the fortress and "Chicheck Tabia."

A battery called "Lelek Tabia (No. 25) was thrown up on the right front of "Yussuf Pasha Tabia" and connected with it on its left flank by a breastwork, a similar line uniting the other flank of the new work with a steep precipice in rear, thus completing the whole chain of inner defences.

Three rows of "troups-de-loup," between three and four feet in diameter, and about the same in depth, were excavated a few yards in front of nearly all the batteries and breastworks: not only the scarcity of wood, but the rocky nature of the ground, prevented the possibility of having pointed stakes driven into the holes, a precaution which would otherwise have been adopted: they were, however, rendered as formidable as possible by piling up the earth, which was taken out, in small heaps between the holes.

No doubt a critical and professional eye would detect many defects in the several works that were thrown up, but the numerous disadvantages under which they were constructed should be borne in mind, and due allowance would then, perhaps, be made. The total want of an engineer establishment; the great and inconvenient extent of ground to be fortified, comprising a circuit of nearly ten miles; the difficulty (and in many places the impossibility) of excavating a ditch, owing to the rocky nature of the soil; and lastly the want of sufficient time, which rendered the preparation of plans quite out of the question, will perhaps be allowed to form almost insurmountable obstacles to a complete and well digested system of fortification. No sooner was a work decided on that it was at once marked out as before stated, and the profiles, made on the spot, were quickly put up, working parties were told off; and the Russian officers, who could from their camp watch the progress of the work, afterwards remarked that the batteries appeared to rise by magic.

The able supervision of Major Teesdale and Captain Thompson (the only two English officers present at Kars besides Her Majesty's Commissioner and Lieutenant Colonel Lake) who were ever ready to afford their assistance, when their other duties permitted them; the cheerfulness and alacrity with which the soldiers worked; and lastly the facilities which were afforded for building, by the quantity of loose stone found in every direction, tended greatly to counterbalance the many disadvantages under which the Engineer officer laboured, and enabled him to complete the fortifications to such an extent as to render the place defensible.

On the 21st of August, when the enemy was seen bringing up some siege guns from Alexandropol, General Williams, having reason to think that they might be intended for the purpose of silencing the heavy guns in "Kanli Tabia," (No. 22) from which the Russians had suffered so severely on the 7th of the same month, directed Lieut. Colonel Lake to strengthen that battery. It was therefore immediately prepared for the reception of some heavy ordnance, by raising three of the barbettes four feet, giving also additional height to the parapet and constructing embrasures. At midnight two heavy siege guns and a 22 oke howitzer were put into position in the battery and masked with gabions. "Kanli Tabia" thus became a most formidable redoubt, and the increased command it obtained served to keep the enemy at a considerably greater distance when attempting to interfere with the foraging party, a matter of no little moment as the pasturage became day by day more scanty.

It should be remarked that the Turkish troops were all under canvass during the whole of the blockade, and the several camps were pitched close to the batteries or immediately in rear of the entrenched lines according to circumstances. In order to protect the tents on the plain below from shot ricocheting into them, should the Russians have attacked that position, parapets were thrown up of the same average section as the breastwork, in the form of a redan, the faces varying with the size of the camp, some of them being three or four hundred feet in length. There were about six or eight of these works, and, being all provided with ditches and banquettes, they would in themselves have presented no trifling obstacle to the enemy had the garrison been forced to make use of them as stepping stones between the outer line of breastwork and the inner line of defence before described, in the event of their being driven in from their first entrenchments.

It has been stated that a kind of open battery (No. 17) was made in the Tachmasb line at the junction of the two breastworks, for guns "en barbette;" not long before the 29th of September it was considered very desirable that this work should be converted into an enclosed redoubt. This was accordingly done, and most fortunate it was that these precautions were taken, for it would have been very difficult, if not impossible, to have held the Tachmasb position for such a length of time on the day of the assault, without the assistance of this important battery, which, after the additions and alterations were made to it, was capable of containing a garrison of from twelve to fifteen hundred men. It may be remarked that the enemy was not aware of the change which had been effected, and was fully prepared to find merely the open work which had originally existed.

On the 29th of September, 1855, Kars was attacked, and after a most severe struggle of upwards of seven hours, the firing never having ceased for one moment the Russians were driven back with heavy loss. The official account of this sanguinary affair has more than once appeared in print, and it is not, therefore, necessary to enter further on the subject in this sketch.* The loss suffered by the enemy on the occasion is a satisfactory proof that the cross fire encountered by the attacking columns was most severe. Much is learnt by experience, and there is no doubt that in lieu of the return on the left flank of the Tachmasb lines, an enclosed battery should have been thrown up, for this position was turned very early in the day: it was, perhaps, too much to expect that it could be held against the overpowering force which was brought against it.

With regard to the English batteries, three of which were taken by the Russians on the 29th of September, not only was the site on which two of them stood faulty in the extreme for the reasons before given, but they were, from wholly unavoidable circumstances, very much under-manned.

The works generally were but very little injured on the day of the assault, and such trifling repairs as were found necessary were completed in a few hours; the magazines stood well and no accident occurred.

Immediately after the battle two star forts (marked A and B), were thrown up, the former on the left of the Tachmasb position, intended to prevent that flank being again turned in case of another attack similar to that of the 29th of September, and the latter to strengthen the English line. An open work (marked C) was also constructed on the edge of the left bank of the river, to hold three guns and a mortar, for the purpose of sweeping the ground lying between Arab Tabia and Kâradâgh. This work commanded Arab Tabia and was planned in such a way as to be useless to the enemy if it fell into his hands, being itself commanded in rear both by the citadel (No. 28) and by Teli Tabia (No. 29).

The soldiers, towards the latter period of the blockade, became so weak and enfeebled from want of proper nourishment that it was with difficulty any work could be done. It was, however, thought advisable to keep them employed, and a barrack to contain three hundred men was marked out in rear of the line between Yussuf Pasha and Chicheck Tabias, in the form of a flêche with a very obtuse angle. The walls were built of rough stone in clay, and the roof, sloping outwards, was made with large beams, laid across from wall to wall, on which planking was nailed, and the whole was covered with earth—the materials were procured from the remains of some old houses close at hand, which had been a short time before partially destroyed for the purpose of obtaining fire-wood for the troops. One of the objects in constructing this barrack, which was only just completed when the place surrendered, was to afford winter quarters for a portion of the garrison in the possible event of Kars being saved even at the eleventh hour.

Various other trifling works were carried on in the mean time, such as raising and strengthening the whole south line of breastwork between Hafiz Pasha and Kanli Tabias, a precautionary measure considered more than ever necessary when the total want of horses rendered it impossible to have any mounted patrols outside the works.

Though physically unable any longer to labour with the same zeal and activity which they had shown in the earlier period of the blockade, the brave Turkish soldiers never complained, even to the last, when called upon to work at the defences—they had seen how completely the fortifications which they had been instrumental in constructing had enabled them to repulse column after column of a force which was strong enough to have nearly annihilated them in the open field, and an anecdote is related of the

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* See the despatch at the end of this paper.—Ed.

Turks that many of them were seen to kiss the batteries at the termination of the battle on the 29th of September, in token of their admiration and gratitude for the shelter which they had afforded them.

All the efforts which were made to hold the place proved utterly fruitless. Starvation effected what the Russians had failed in accomplishing with the bayonet, and, on the 28th of November, 1855, after a blockade of nearly six months, Kars surrendered at discretion to as gallant an enemy as ever sat down before a fortress.[*]

DESPATCH

Extracted from the *London Gazette Extraordinary* of November 10, 1855.

FOREIGN OFFICE, November 10.

The Earl of Clarendon has received a despatch from Major General Williams, Her Majesty's Commissioner with the Turkish Army in Asia, of which the following is a copy :—

"KARS, October 3.

"My Lord,—I had the honour to announce to your Lordship, on the evening of the 29th ult., the glorious victory gained on the morning of that day by the Sultan's troops on the heights above Kars, over the Russian army commanded by General Muravieff, and I now beg to furnish your Lordship with the principal incidents of that sanguinary battle.

"Your Lordship will, perhaps, recollect that in my despatch, No. 123, of the 28th of June, I stated that the Russian General, after his second demonstration against the southern face of our entrenchments, which is flanked by Hafiz Pasha Tabia and Kanli Tabia, marched south, and established his camp at Bugah Tikmé, a village situated about four miles from Kars. Knowing that General Muravieff served in the army which took Kars in 1828, I conceived his last manœuvre to be preparatory either to a reconnaissance, or an attack upon the heights of Tahmasb, whence the Russians successfully pushed their approaches in the year above cited.

"While, therefore, the enemy's columns were in march towards Bugah Tikmé, I visited those heights with Lieutenant-Colonel Lake, and, after studying the ground. decided upon the nature of the works to be thrown up ; these were planned and executed by Lieutenant-Colonel Lake with great skill and energy. I enclose for your Lordship's information a plan made by that officer of the town and its neighbouring heights, which are situated on the opposite side of the river of Kars Chaï, over which three temporary bridges had been thrown to keep up our communications. As all verbal descriptions or bird's-eye views of ground convey but an imperfect idea of any locality, I beg to enclose a sketch made by Mr. Churchill, which will, I trust, tend to elucidate my description.

"Your Lordship will observe that, while our camp and magazines in the town were rendered as safe as circumstances would allow, the hills above Kars command all, and were, therefore, the keys of our position.

"The entrenchments of Tahmasb, being those nearest the enemy's camp, demanded the greatest vigilance from all intrusted with their defence. General Kmety, a gallant Hungarian officer, commanded the division which occupied this eminence ; he was assisted by Major-General Hussein Pasha and my Aide-de-Camp, Major Teesdale, who has acted as his Chief of the Staff.

"Throughout the investment, which has now lasted four months, the troops in all the redoubts and intrenchments have kept a vigilant lookout during the night, and, at their appointed stations, stood to their arms long before daydawn. In my despatch, No. 155, of the 29th ult., I informed your Lordship of the arrival of the news of the fall of Sebastopol, and of the landing of Omar Pasha at Batoum. I also acquainted your Lordship with the fact that the Russian General was engaged in sending off immense trains of heavy baggage into Georgia and showing every indication of a speedy retreat. This in no wise threw us off our guard, and Lieutenant-Colonel Lake was directed to strengthen many points in our extensive and undermanned lines, and among other works the tabia bearing my name was constructed.

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[*] The despatch which describes the attack of the position on the 29th September, 1855, is added as a record of the capabilities of Turkish troops when well directed, and aided by judiciously planned works.—ED.

"At 4 o'clock on the eventful morning of the 29th the enemy's columns were reported to be advancing on the Tahmasb front. They were three in number, supported by 24 guns; the first or right column being directed on Tahmasb Tabia, the second on Yukseh Tabia, and the third on the breastwork called Rennison Lines. As soon as the first gun announced the approach of the enemy the reserves were put under arms in a central position, from which succours could be despatched either to Tahmasb or the English lines.

"The mist and imperfect light of the dawning day induced the enemy to believe that he was about to surprise us; he advanced with his usual steadiness and intrepidity; but on getting within range he was saluted with a crushing fire of artillery from all points of the line. This unexpected reception, however, only drew forth loud hurrahs from the Russian infantry as it rushed up the hills on the redoubts and breastworks. These works poured forth a fire of musketry and rifles which told with fearful effect on the close columns of attack, more especially on the left one, which, being opposed by a battalion of 450 Chasseurs, armed with Minié rifles, was, after long and desperate fighting, completely broken and sent headlong down the hill, leaving 850 dead on the field, besides those carried off by their comrades.

"The central column precipitated itself on the redoubts of Tahmasb and Yuksek Tabias, where desperate fighting occurred and lasted for several hours, the enemy being repulsed in all his attemps to enter the closed redoubts, which mutually flanked each other with their artillery and musketry and made terrible havoc in the ranks of the assailants; and it was here that Generals Kmety and Hussein Pasha, together with Major Teesdale, so conspicuously displayed their courage and conduct. Lieut.-General Kereen Pasha also repaired to the scene of desperate strife to encourage the troops, and was wounded in the shoulder and had two horses killed under him.

"The right column of the Russian infantry, supported by a battery, eventually turned the left flank of the intrenched wing of the Tahmasb defences, and while the Russian battery opened in the rear of the closed redoubt at its salient angle their infantry penetrated considerably behind our position.

"Observing the commencement of this movement, and anticipating its consequences, Lieutenant-Colonel Lake, who had taken the direction of affairs in the English Tabias, was instructed to send a battalion from Fort Lake to the assistance of the defenders of Tahmasb, and at the same time two battalions of the reserves were moved across the flying bridge and upon the rocky height of Laz Jeppé Tabia. These three reinforcing columns met each other at that point, and being hidden from the enemy by the rocky nature of the ground confronted him at a most opportune moment. They deployed, and opened their fire, which stopped and soon drove back the enemy's reserves, which were then vigorously charged with the bayonet, at the same moment when General Kmety and Major Teesdale issued from the redoubts at Tahmasb and charged the assailants. The whole of that portion of the enemy's infantry and artillery now broke and fled down the heights under a murderous fire of musketry. This occurred at half-past 11, after a combat of seven hours.

"In this part of the field the enemy had, including his reserves, 22 battalions of infantry, a large force of Dragoons and Cossacks, together with 32 guns.

"While this struggle which I have attempted to describe was occurring at Tahmasb a most severe combat was going on at the eastern portion of the line, called the English Tabias.

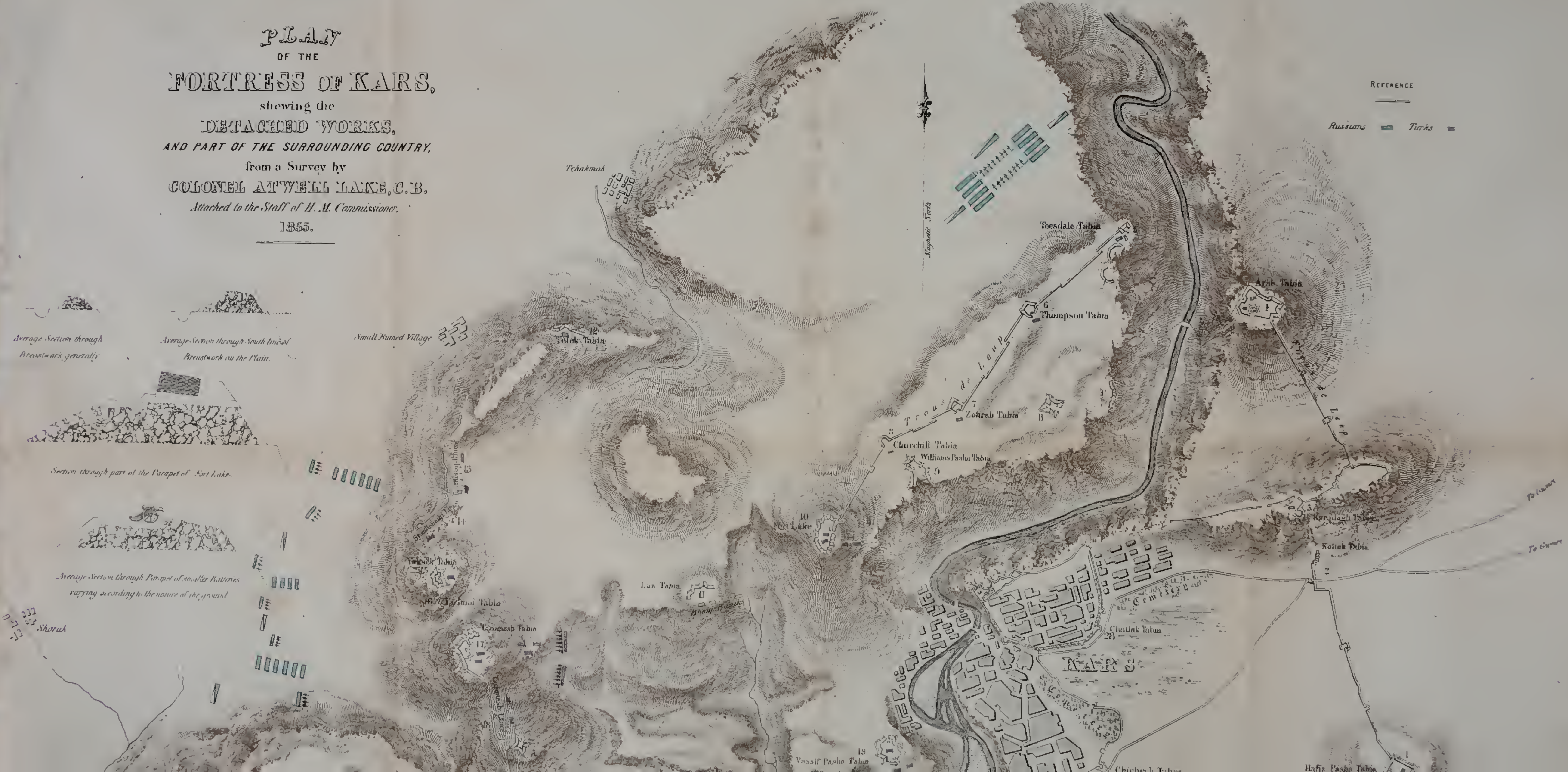
"About half-past 5 o'clock, A.M., a Russian column, consisting of eight battalions of infantry, three regiments of cavalry, and 16 guns, advanced from the valley of Tchakmak, and assaulted those small redoubts, which, after as stout a resistance as their unavoidably feeble garrisons could oppose, fell into their hands, together with the connecting breastworks, defended by townsmen and mountaineers from Lazistan, whose clannish flags, according to their custom, were planted before them on the epaulments, and, consequently, fell into the enemy's hands; but ere the firing had begun in this portion of the field Captain Thompson had received orders to send a battalion of infantry from each of the heights of Karadagh and Arab Tabia to reinforce the English lines. This reinforcement descended the deep gully through which flows the Kars river, passed a bridge recently thrown across it, and ascended the opposite precipitous bank by a zigzag path which led into the line of works named by the Turks 'Ingliz Tabias' (the English Batteries). Their arrival was as opportune as that of the reserves directed towards Tahmasb, which I have had the honour to describe in the former part of this despatch. These battalions, joined to those directed by Lieutenant-Colonel Lake, gallantly attacked and drove the Russians out of the redoubts at the point of the bayonet, after the artillery of the enemy had been driven from those lines by the cross fire directed from Fort Lake, and from Arab Tabia and Karadagh by Captain Thompson. This officer deserves my best thanks for having seized a favourable moment to remove a heavy gun from the eastern to the western extremity of Karadagh, and with it inflicted severe loss on the enemy.

"After the Russian infantry was driven from the English redoubts, the whole of their attacking force of cavalry, artillery, and infantry retreated with precipitation, plied with round shot from all the batteries bearing on their columns. During their temporary success, however, the enemy captured two of our light guns, which the mortality among our horses from famine prevented our withdrawing from their advanced position. He also carried off his wounded and many of his dead; yet he left 363 of the latter within and in front of these intrenchments; and his retreat occurred at least an hour before the assailants of Tahmasb were put to flight.

"During this combat, which lasted nearly seven hours, the Turkish infantry, as well as artillery, fought with the most determined courage; and when it is recollected that they had worked on their entrenchments and guarded them by night throughout a period extending to nearly four months, I think your Lordship will admit that they have proved themselves worthy of the admiration of Europe, and established an undoubted claim to be placed among the most distinguished of its troops.

"With regard to the enemy, as long as there was a chance of success he persevered with undaunted courage, and the Russian officers displayed the greatest gallantry. Their loss was immense; they left on the field more than 5,000 dead, which it took the Turkish infantry four days to bury. Their wounded and prisoners in our possession amount to 160, while those who were carried off are said to be upwards of 7,000.

"As the garrison was afflicted with cholera, and I was apprehensive of a great increase of the malady should this melancholy duty of the burial of the dead not be pushed forward with every possible vigour by our fatigued and jaded soldiers, I daily visited the scene of strife to encourage them in their almost endless task; and I can assure your Lordship that the whole battle-field presented a scene which is more easy to conceive than to describe, being literally covered with the enemy's dead and dying.



PLAN
OF THE
FORTRESS OF KARS,
shewing the
DETACHED WORKS,
AND PART OF THE SURROUNDING COUNTRY,
from a Survey by
COLONEL ATWELL LAKE, C.B.
Attached to the Staff of H. M. Commissioner.
1855.

Average Section through Breastworks generally

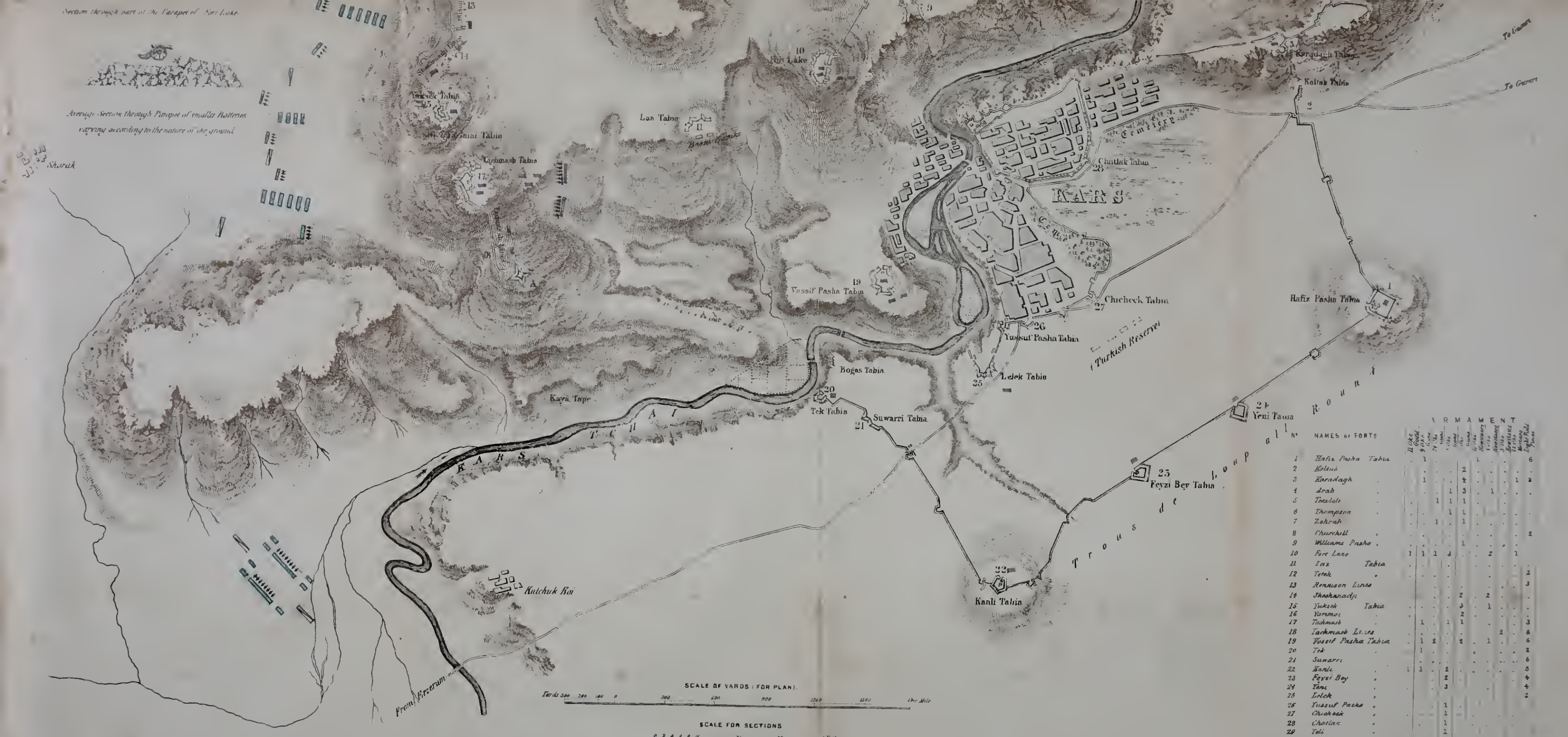
Average Section through South line of Breastwork on the Plain.

Section through part of the Parapet of Fort Lake.

Average Section through Parapet of smaller Batteries varying according to the nature of the ground

REFERENCE

Russians ▬ *Turks* ▬



Lithographed & Printed at the Topographical & Statistical Depot War Depart

ARMAMENT

Nº	NAMES of FORTS	18 Oke Guns	9 Oke Guns	7½ Oke Guns	[illegible] Oke Guns	[illegible] Oke Guns	[illegible] Oke Howitzers	[illegible] Oke Howitzers	3 Oke Howitzers	[illegible] Mortars	Light Field Guns
1	Hafiz Pasha Tabia	.	1	.			1	.	.		6
2	Kolaiu		.	.	.	2	.	.	.	.	.
3	Karadagh .		1	.	.	4	.	.	.	1	2
4	Arab .	.	.	.	1	3	.	1	.	.	.
5	Teesdale .	.		1	1	1	.		.		
6	Thompson .	.	.		1	1	.		.	.	.
7	Zohrab	.	.	1	.	1	.	.	.	.	
8	Churchill .	.	.	.	.	.	.	.	.	.	2
9	Williams Pasha .	.	.	.	.	1	.	.	.	.	
10	Fort Lake	1	1	1	3	.	.	2		1	
11	Laz Tabia	.	.		.		.	.	.	.	.
12	Tetek .	.	.	.	.			.			2
13	Rennison Lines			.	.	.		.	.	.	3
14	Shoshanadji			.	.	2	.	2	.		.
15	Yuksek Tabia	.	.	.	.	3	.	1	.	.	.
16	Yarimoi .	.		.		2	.		.	.	.
17	Tachmasb .		1	.	1	1		.		.	3
18	Tachmasb Lines	.	.	.	.	.			2	.	6
19	Vassif Pasha Tabia	.	1	2	.	2	.	1	.	.	6
20	Tek .		1	.	.		.		.	.	2
21	Suwarri		.	.	.	.	.	.	.	.	6
22	Kanli .	1	1	.	2	.	.	.	.	.	8
23	Feyzi Bey .			.	2	.				.	4
24	Yeni .	.		.	3			.			4
25	Lelek .										2
26	Yussuf Pasha .			.	1	.					
27	Chichock .	.			1				.	.	
28	Chatlak .		.		1		.	.		.	
29	Teli .				2						
30	Citadel .		1		2				.		
A B C	Forts constructed since the Battle										
	Reserve										6
	TOTAL	2	8	5	20	23	1	7	2	2	64

Note 1 Oke = 2.8286 English avoirdupois Pounds

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"The Turkish dead and wounded were removed on the night of the battle. The dead numbered 362, the wounded 631. The townspeople, who also fought with spirit, lost 101 men.

"His Excellency the Mushir has reported to his Government those officers who particularly distinguished themselves—a difficult task in the army which has shown such a desperate valour throughout the unusual period of seven hours of uninterrupted combat.

"I have, &c.,

"W. F. WILLIAMS.

"The Earl of Clarendon, &c."

List of Tools Employed in Constructing the Defences of Kars in 1855.

248	Picks.
135	Iron shovels.
32	Do. crowbars.
40	Hammers for breaking stone.
472	Turf cutters.
20	Trimmers.
4	Turf shovels.
23	Grass knives.
6	Crowbars.
4	Fascines chokers.
6	Gabion gauges.
12	Sap hooks.
6	Pickets.
4	Ropes.
14	Planes.
9	Saws.
4	Hatchets.
6	Adzes.
5	Axes.
18	Gimlets.
6	Pairs of pincers.
16	Trowels.
33	Tracing lines.
28	Horsehair sacks.
6	Iron Wedges.
3	Double-handed saws.
400	Pick handles.
200	Platform planks.
200	Common do.
200	Profile boards.
4	Pairs of compasses.

PAPER VII.

REMARKS ON THE PREPONDERANCE OF THE ATTACK OVER THE DEFENCE IN SIEGES, AND ATTEMPTS TO ANALYZE THE VALUES OF FORTIFIED PLACES, WITH SOME DESULTORY OBSERVATIONS ON SIEGE OPERATIONS.

By MAJOR GENERAL LEWIS, C.B, Royal Engineers.

Vauban first destroyed the preponderance of the defence, and then attempted to re-establish it, but failed, like other projectors up to this time, it having been attempted by Carnot and also by Bordwine and Fergusson. The two last were civilians, and their views were based only on theory. The latter seems to be a copyist of Carnot's "Fortification Primitive," and this is a work which should be read by all military men and studied by the Engineer officer, notwithstanding that Carnot was not successful in his scheme of defence.

The reputation won in the defence of fortified places is frequently gained, not by the intrinsic value of the works, but by fortuitous circumstances, as in the case of Sebastopol; and many strong places have brought the art of fortification into disrepute by the shortness of their defence, hence the difficulty of persuading the people of this country of its full value. Eighty years since Charles Duke of Richmond tried to introduce a scheme of defence for the protection of our coasts and naval arsenals, without success at that time; and such of his projects as have been carried out have been executed under the pressure of the moment at long intervals. With these impressions, it is proposed to analyze the value of fortified places, by referring to some of the sieges and to the nature of the works defended during the last half century, and to explain that some of the successful defences depended more upon circumstances than upon the skill of the Engineer employed in the construction of the works. This analysis or explanation should be considered by military men and statesmen, to prevent a false estimation of works of defence being formed, and to enable them to appreciate and understand the accidental circumstances which led to happy results, such as the nature of the garrison and the habits of the population, who, from patriotism, enthusiasm, or religious feeling, have run the chance of sacrificing themselves and their families. Again, there is the aptitude of some nations for converting a place hardly tenable into one that is strong, for which the Americans, Turks and Russians are remarkable; and it seems that some nations most deficient in the art of war possess this faculty.

So it sometimes happens that a place is attacked which had originally only a small capacity for defence, and whilst preparations are being made to besiege it "en règle," with a moderate siege equipment, up starts a fortress of the first class. This occurred at Fort Erie in North America, at Cadiz in 1810-11, at Silistria on the Danube in 1854, and at Sebastopol in 1855.

Sometimes too much value is given to circumspection, or there is want of audacity in making use of some accidental advantage; for every siege equipment should afford the means of converting a regular attack into an "attaque brusque" or an "attaque accélérée," for instance a large supply of scaling ladders, mining apparatus to break down stockades and barriers, and Blanshard's light cylindrical pontoons for crossing wet ditches.

The Chief Engineer has a difficult task in recommending a plan of attack; probably if young he will be all audacity, having a reputation to gain, whilst an old experienced one of high reputation and talent may propose caution. A General Commanding-in-Chief, therefore, should weigh these matters, enquire into the resources of his command, make a close and searching reconnaissance of the strength of the place, and judge for himself how to proceed.

There is nothing so disheartening and even demoralising to an army as a protracted siege, and little is gained by one in blood or money, therefore every means practicable should be adopted to shorten it if an "attaque brusque" or a surprise can assist in taking the place; and again there is much lost by sitting down before one with insufficient means. The Duke of Wellington occupied a whole winter in collecting means for the attack of Ciudad Rodrigo in Spain, and the place fell in 16 days. In our time we sit down before a place without resources for a siege, and find the means afterwards.

These mistakes, or want of judgment, give an importance to a work which it does not merit. Burgos, a mere field work for about 1,500 men, on a strong eminence, obtained a reputation, and is thought to be a strong fortress, in consequence of the efforts of a determined garrison against an attack made with inefficient means.

The study of sieges would be useful to General Officers, who are sometimes led into difficulties by the too sanguine views of professional men, as they are termed, and they will find that there is nothing so certain or bloodless as an "attaque en règle" with ample means, ample in men and money, in Artillery and Engineer equipment, and in all the appliances of attack, combined with the adoption of an "attaque accélérée," if the opportunity offers. We should give a greater value to vertical fire than is now admitted, for it is not every nation that can sacrifice 1,000 men a day under its effects like the Russians; and mortars, where works are well covered from direct fire, and where bomb-proof cover is deficient, should form a large proportion of siege artillery.

But audacity, judgment and skill should be the moving powers, backed by an ample supply of all siege resources. Judgment failed in the siege of Valenciennes, in 1795, when the wrong side for the attack was selected by the Austrians, although they showed no want of skill or resolution in the attack; skill was deficient in our attacks of Dunkirk in the same year, and of Bergen-op-zoom, in 1814, when a first class fortress very nearly lost its reputation; and sometimes audacity is wanted, or the moral courage to risk a little for a great probable gain.

Again places gain a reputation by the patriotism of the defenders, like Saragossa and Gerona in Spain, and thus baffle judgment, skill and audacity, the former having only an imperfect enceinte, without ditch or covered way. The defence of Kars is the last example of this, and proved that a fortified place, having no pretensions to the denomination of a fortress, may gain celebrity entirely by the skill and resolution of its defenders.

It may be demanded—why go to the expense of constructing fortresses if mere walled towns, or accidental positions, can be formed into places of equal value? In reply it must be observed that you cannot always calculate upon the resolution of the defenders or their willingness to undergo the horrors of a siege, nor can you always depend upon an enemy wanting audacity, skill or the means of attack.

Yet the recently constructed first class fortress of Rastadt, near the upper Rhine, built with all the skill of modern art, for a protracted defence, may possibly disappoint the expectations entertained, because the facilities of attack are so great, as it is close to the fortress and arsenal of Strasbourg, from whence can be drawn all the resources for a siege, the interval being only a few miles with excellent roads.

Therefore in addition to local advantages and skill in fortifying a place to secure a protracted defence, the *position* must likewise be considered, and the means which an enemy may have for its attack. A power commanding the sea generally commands all maritime fortresses, which, if distant 50 miles from it, might be unattackable, from the difficulty of transporting to that distance a siege equipment; and probably in the latter case half the expense of the construction of the fortress may be saved. Thus Pampeluna was unattackable in 1813-14, on account of the difficulty of conveying the means of attack.

These are questions for careful consideration, in making projects of defence. General Lloyd, who in a former volume has been quoted, observes that in selecting a site for a fortress, the question of how it can be relieved is of the first importance, for the strength is of little value if it can be starved out, as was the case with Malta in 1801.

Towards the restoration of the preponderance of defence over attack, the Engineer must put on one side the pedantry of schools and systems, looking to the site in the adaptation of the schemes of the old and new projectors, without being circumscribed by rules as to the lines of defence, which the improvements in small arms and gunnery render unnecessary, but looking to the first principles taught by Vauban, viz. :—

" That every part of the fortress accessible should be seen from some collateral work.

" That it should be 'hors d'escalade,' the escarps not being less than 39 feet high, if not surrounded by wet ditches.

" To afford sufficient bomb-proof cover for stores, ammunition and hospitals, also for a certain proportion of the garrison (as laid down in the Aide-memoire to the Military Sciences, article 'Defence.').

" To prevent the escarps from being seen from without as much as possible, at any rate from being breached from a distance.

" That the enceinte should have such out-works and covered-way as will secure a safe egress and ingress for the garrison on those sides of the fortress which may be open to attack.

" To have a system of mines where practicable.

" Finally, to secure an inner defence or line parallel with the fronts attackable. At New Brisach the defence was doubled by adding the inner line, according to Vauban's 3rd System.

Working upon the above-mentioned principles, the preponderance of defence in the case of any fortress with local advantages, and with a determined garrison, will be in proportion to the number of these rules which can be carried into execution. And it should be borne in mind that in some positions a few only of the resources of art will suffice, the case, for instance, of a mere enceinte, with a few outworks, or an enceinte for the support of a system of detached works, as at Paris, or one in which the position or line of defence is to be made complete, in the time of emergency, with strong field-works or works of the moment.

These remarks should be well considered by statesmen as well as military men, when they authorize great outlays of money in works of defence, that they may not sanction a great expense to satisfy the ingenuity of the Engineer. Above all, a statesman should eschew all small isolated works, except in very peculiar sites in mountain districts or marshy spots almost inaccessible. Again there are places, such as Dover and Portsmouth, where no outlay can be too great to make them secure.

In concluding this attempt to analyze the value of fortresses, it is desirable to record the names of those places which have maintained their reputations and justified the great outlay on the construction of their works, viz.:—the citadels of Lille and Turin, the fortresses of Malta, Mantua, Mayence, Bayonne, Magdebourg, and Ismail on the Danube, also Bergen-op-Zoom, which however nearly lost its reputation in 1814. Then again other places, such as Gibraltar, Genoa, Cadiz, Dantzic and Verona have gained a celebrity, owing to their fortunate positions, as well as to the skilful construction of their works.

Those fortified places which have obtained a meretricious reputation from accidental circumstances have been partially adverted to, and should be rarely quoted in valuing the strength of works, except with an explanation of those circumstances. In considering the recent defence of Sebastopol, it requires great discrimination to understand its value, and to judge of what produced the result of a protracted siege and a most sanguinary defence. It was not the skill in the construction of the fortifications, which were mostly works of the moment, well adapted to the contour of the ground; but it may be assumed that the protracted defence arose from the inadequacy of the means of attack in the first instance, and from the impractibility of investing it; for the position of Sebastopol is like that recommended by General Lloyd for a fortress at the junction of two rivers, since it requires two armies to blockade it. Then there were the vast resources of a naval arsenal, of ordnance, ammunition, stores, and timber for blindages, the aid afforded by 12,000 seamen, accustomed to manœuvre heavy artillery, and the frequent reliefs of the garrison by troops willing and determined to save the honour of their country; all which combined to throw an imperishable lustre on the defence, most favourable to the reputation of the Russian army. This explanation of the siege of Sebastopol must be borne in mind, when the value of fortified places is taken into consideration, and its defence is brought forward as an example.

The preponderance of the attack over the defence of fortresses in sieges, secured by Vauban by the introduction of ricochet fire against all works open to enfilade, can only be evaded by local advantages, admitting of fortifying on nearly a straight line, where the outline of the works is necessarily polygonal, or where they are traced so that the prolongations of the faces fall upon some ground or space that cannot be occupied by ricochet batteries. This advantage of employing enfilading batteries as well as Vauban's mode of advancing by zigzag upon the salient angles, and pushing the trenches by sap to the covered way or counter-scarp, together with an ample supply of vertical fire, give the besiegers such a superiority and power, by first embracing and encircling the fortress, and then attacking with resources in men &c., which should be at least three times those of the garrison, that the place, if left without chance of relief, succumbs as the inevitable result, in the course of a few weeks.

If this preponderance does not prevail, the defects in science or in the art of attack will not be the cause, but probably the want of means, for a siege equipment is one not easily collected, or transported, since it requires, if carried by sea, the tonnage of some hundreds of vessels, or some thousands of waggons, if transported by land. But if a powerful nation can secretly or openly provide the means of attacking a neighbouring fortress, it will, when invested, fall as assuredly as the days pass away in the siege operations.

At the risk of being tedious, and of repeating what has been before explained, it may be stated that if a place has unexpectedly gained a reputation to which it was not entitled according to the rules of art, it has arisen from accidental circumstances, from the want of the means of attack, or from the besiegers miscalculating the resources of the defence.

In proportion therefore to the probable resources of an enemy for attack, and the facility which he may possess of transporting an army and a siege equipment for the reduction of fortified places, must the skill of the Engineer, and the pecuniary means of a nation be devoted to strengthen them, instead of expending money upon positions unsusceptible of attack, and remote from any powerful neighbour, when the difficulty of transporting the means of attack is in geometrical proportion to the distance.

In respect to siege operations which the late war brings to mind, and which seem to lead to surmises that the defence of places is gaining its lost ground, because two powerful nations entered into active operations without being prepared, we should consider the vast resources for attack that were accumulated when once the means of those nations were called out (vide paper V. in this volume), and that when these were obtained success followed.

To render this power of attack available in another war, we want at all times a large Engineer Corps, well trained in sapping and mining, and in the construction of works, *not* organized at the moment of need, but as a *permanent* part of our military establishments. In the Crimea we should have had battalions where we had companies.

It is to be borne in mind that the British soldier has a dislike to the shovel and pick, and that he is supported in this dislike by the prejudices of the officers, partly from indifference and partly from imperfect knowledge of the science of fortification. The soldier in the trenches should receive a small sum, say a penny an hour, to cover the wear and tear of clothes, and additional food to sustain him, on the certificate of the directing Engineer, when the working party returns to camp, on a numerical list, and to be given to the senior officer of each corps in charge of a party. It was done in the Mediterranean by the issue of spirits, but was not followed up by the Duke of Wellington for want of pecuniary means.

But the point of first importance to the success of siege operations is the strength of the Engineer Corps, which should be such that two or three battalions of military workmen could be assembled at one point; the last war, and the operations in the Crimea especially, produced improvements in this respect, as compared to the state of our service in former wars, although the number was still far short of the actual wants.

It has been before suggested by the author of this paper that advantage would accrue from the introduction into siege operations of the 6¼ inch mortar, we have 6¼ inch shells, and 6¼ inch howitzers; and the use of the 6¼ inch mortar, in the third parallel, and trenches in advance of it, would assist the operations of the sapper in approaching the counter-scarp. It is suggested likewise that every howitzer should be mounted on such a carriage that it could fire over a "genouillère" of 4′ to 4′ 6″ high, and thus save the cheeks of the embrasures, the soles of which should slope inwards similarly to the superior slopes of the parapets of mortar batteries.

G. G. L.

Paris, February, 1857.

PAPER VIII.

ON COAST DEFENCES.

By GENERAL SIR JOHN F. BURGOYNE, Bart., G.C.B., &c.,
Inspector-General of Fortifications.

The first study of an Engineer in fortifying should be how to turn to the greatest possible account every advantage afforded him by nature; with the object of obtaining the largest power of resistance by the smallest expenditure and efforts: high and steep escarpments of rocks, inundations in very low lands, &c., form the cheapest impediments to the approach of an enemy, and are usually much more efficient and powerful than what are purely artificial.

This principle is so self-evident that it is rarely absolutely counteracted; though it is not very unusual to find it partially neglected. A striking instance of the former error may be remarked in the fortifying of Syracuse in Sicily, where a low marshy neck of land, that was in front of the peninsula on which the modern town stands, instead of being improved into a formidable barrier by excavations, has been made into firm land, at an expense that has given it the name of the Monte d'Oro, on which to place a weak line of works of defence!

Where we witness perhaps most frequently the partial neglect of advantages afforded by nature, is in works devised for occupying points of land projecting into the sea, having comparatively narrow fronts across their necks.

It is not unusual to find, on such a point, a regular enclosed fort of equal or nearly equal strength all round; whereas the only side by which it can be approached is that towards the land, except by that most desperate of attacks—an assault from boats.

It is submitted that the proper mode of occupying such points would be by a strong line across the neck, from sea to sea, and a comparatively very slight one round the contour of the other sides. And we can scarcely conceive a position where this would not be the preferable course: in the accompanying figures 1 and 2, A represents the system frequently adopted; while the land front B C, and the contour D E F show the one here advocated. All the most improved means of artificial defence may be extended to the front B C, and work upon work added to any extent to prolong its capability of resistance; but one definite, final, simple system will be sufficient for the line round the shore. By this mode, expense will be saved; because every part of the work will tend to a useful object, and not be lavished where not necessary. Much more space will be enclosed (a matter of great importance in detached works), which can be defended by the same garrison, and a greater front opposed to the enemy on the only side by which he can approach.

The only point which, it is conceived, will require explanation, will be to show the adequacy of the proposed simple line round the sides washed by the sea.

An advance by boats towards a shore lined by works, from whence would be directed showers of shot, shells, grape, rockets and musket bullets, must lead to heavy losses in the boats, and to such confusion among the troops who might reach the shore as to render them quite incapable of attacking the most simple line of entrenchment (that is, one that is well flanked and presents a tolerable obstacle). The chief reliance of a force attempting such an assault would be on a power to silence the guns, and destroy the defences and the impediments to the assault, by the covering fire from their men-of-war, gun boats, floating batteries, &c.

Where such a proceeding is considered practicable, it is usually where a single, exposed, unbroken line-wall is the only barrier; and, whether with or without casemates, there cannot be a doubt but that a concentrated heavy fire from ships would silence the guns immediately exposed to it, and would do extensive damage to the wall, or perhaps even open it partially; but, even in this worst case, those guns only would be silenced that were immediately subjected to that concentrated fire; those that were right and left would still remain in action, unless the naval force brought against it should be sufficiently powerful to embrace the whole extent; and in proportion as the guns on the line were dispersed would the fire from ships be ineffective.

Assuming, however, the cannonading to have been as successful as anticipated, still, the storming by men landing from boats would be very hazardous, in face of even a small force or garrison, among the ruins and broken ground; for the entrance, even if unopposed, would assuredly be anything but smooth or easy.

With a knowledge of the defects of defences so circumstanced, many resources may be adopted to render the assault itself most difficult, by interior cover, enclosures, and obstacles that could not be reached by the cannonading.

This, however, is supposing the coast line or enclosure to be of an old and most unfavourable description; it is supposing its primary obstacle, the wall, to be liable to be utterly destroyed and to be without flanks; but where we have now to establish a defensive line the measures taken would be different.

These and the following remarks are intended to meet the too confident opinions of many energetic officers of the navy, who are inclined to over-estimate their power of attack on works on shore; and to point out a few of the precautions that may be taken to oppose them with effect.

One of the greatest advantages that nature can offer would be (what is not unusual in such positions) a high rock which either is, or could be made, for heights exceeding 20 feet, too steep to be climbed without ladders; such a line could clearly not be breached; and, with an efficient parapet of earth, to cover the men above, and thoroughly flanked, would be unassailable from afloat.

If the line-wall, though exposed, be substantial, tolerably high, and backed with earth, the difficulty of opening it effectively from the sea will be very great; nor is it upon record, it is believed, that it has ever been effected. To make a practicable breach, of even limited extent, in such a construction, requires time and a considerable expenditure of ammunition, even from batteries on shore, where the fire is very precise, and may be very close; and it could hardly be effected at all from shipping; or even if it were, the opening would be narrow, and if flanked, would be such as not to be considered assailable by a storming party from cover that is at all distant, though the interval could be traversed rapidly, and the assault made by troops in a compact mass, which is very different from the slow and dispersed manner in which it must be made by landing from boats, when, previous to the actual landing, any fire must have a most discouraging effect, motionless and helpless as the troops must feel in them. If the wall, however, either as an escarp or counterscarp, is the lining of a ditch, or otherwise covered from view, it is clear that it cannot be injured by the cannonading; and the same may be said of any other good obstacle so covered. The great desideratum then is to secure an obstacle or impediment of any kind to the advance of a storming party, that shall create a difficulty and require a little time to be passed, and that cannot be opened or reduced by the fire from the vessels. In the Mediterranean they apply an admirable one occasionally, by forming a line of breakwaters of loose rocks, parallel to the shore, and at such a distance as shall leave a depth of 5 or 6 feet of water within, the coast being rocky, and without tides, and the sites not exposed to very heavy seas.

The flanks are even of more importance than the obstacle, because, however imperfect the latter may be, provided it occasion some difficulty and delay, it could hardly be forced, if under a good intact flanking fire.

It is not difficult to provide for the security of the flanks, for while every line that is parallel, or nearly so, to the shore, may be fully battered by the vessels, those which recede from it at a great angle, as the flanks would do, cannot be opposed by a direct fire, without the ship being placed in the most inconvenient and dangerous position; this is so much the case that even the heaviest guns to oppose the ships themselves may sometimes be advantageously so placed; each, in that case, not engaging them directly, but attacking collaterally those that are opposite the next front.

The only means by which these flanks then can be opposed, is by "lobbing" or vertical fire of shot or shells on their prolongations; but that fire must be very precarious and inefficient, because it is scarcely possible for the ships exactly to ascertain the precise line of prolongation, or the precise distance. The flanks also are but short, and would be provided with traverses, or, for extra and certain precautionary defence, might have bomb-proof cover over the platforms.

The most effective flanking works, however, to resist an assault, are "caponnières" or casemates. Of all modes of opposing a storming party, a fire upon it from loopholes is by far the most discouraging, and, if it is from a flanking position, the most destructive; the assailants feel perfectly helpless against it, for they receive blows without a power of returning them, and under an impossibility of grappling with their enemy; however short too such flanks may be, the fire from them may be very heavy, for, from each single loophole, having one man to fire, with several to load for him, the shots will follow in very rapid succession.

The absolute necessity for securing the line along the sea fronts from being turned by an advance along the shore, from the land side, will of course be understood, and this can usually be effected with facility by providing covered obstacles with a heavy fire upon them; the only other precaution, to which it seems necessary to advert, is to defilade these line-walls from the land side by the covering mass of the land front of defence. Against ricochet fire sufficient traverses should be applied, and against a general enfilade and vertical fire it would be necessary to have recourse to bomb-proof cover over the gun platforms, or over such a number of them as may be thought sufficient.

On the whole, it may be understood that a line along a shore may be perfectly fortified against any assault from afloat, by very moderate means, and by works of a far less costly and elaborate character than those applied to land defences; and, consequently, that the application of expensive ones to such situations, which has not been unusual, is bad economy, besides being attended with loss of space and other inconveniences.

The main object in the occupation of these positions is generally to enclose sites for sea batteries for the protection of harbours and coasts; and by the system here urged much more space is obtained for them, so that they can be more dispersed, and may be either along the line overhanging the shore, or within it, as the ground or other circumstances render eligible.

In discussing the relative powers of ships and floating batteries against shore defences, it is not uncommon to advert to the step in advance in favor of the vessels, made by covering their sides with sheet iron, which renders them partially shot-proof; and to anticipate the further progress of obtaining increased power of resistance against an enemy's fire by that means. All this is quite just; but it must be observed that, up to the present time, the protection is somewhat imperfect, that the ships are not capable of resisting the effect of pieces of the heaviest calibre with which the shore batteries are now being armed, that, although they can stand against occasional shots of a smaller calibre, a heavy fire on them from the same would no doubt eventually penetrate, and, above all, that the decks, which, under many circumstances of exposure to the fire of elevated batteries, or of great elevation given to guns, will be liable to receive shot and shells, are totally unprotected, and, even with the imperfect protection that these vessels have obtained, they are as yet scarcely sea worthy; but, on that account, are far better adapted to *defensive* operations in smooth waters, and to co-operate with the shore batteries than to act against them; still, though the expense will be very great, it is quite reasonable to anticipate further improvements; but it is not to be supposed that progress will not, at the same time, be made in the improvement of the shore batteries, by the application to them also of iron covering, and of pieces of even larger calibre than those at present used, such as are already in progress of experiment, and by which they may be expected fully to retain their relative advantages.

These same principles will usually apply to the protection of such small islands as are capable of being defended as a whole.

J. F. B.

FIG. 1.

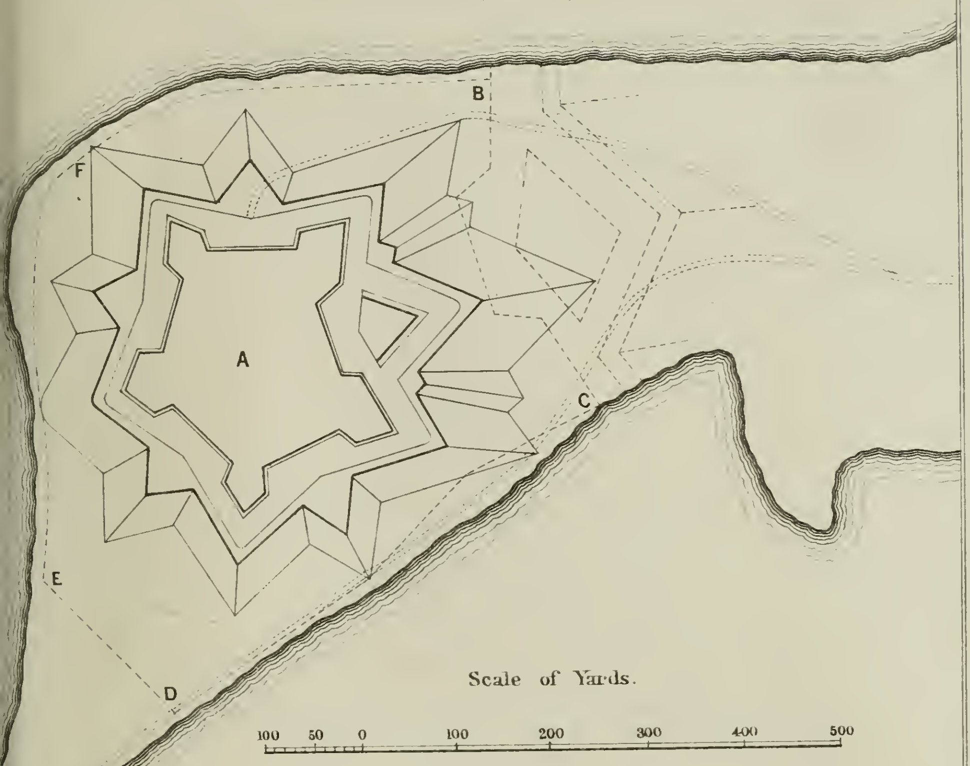
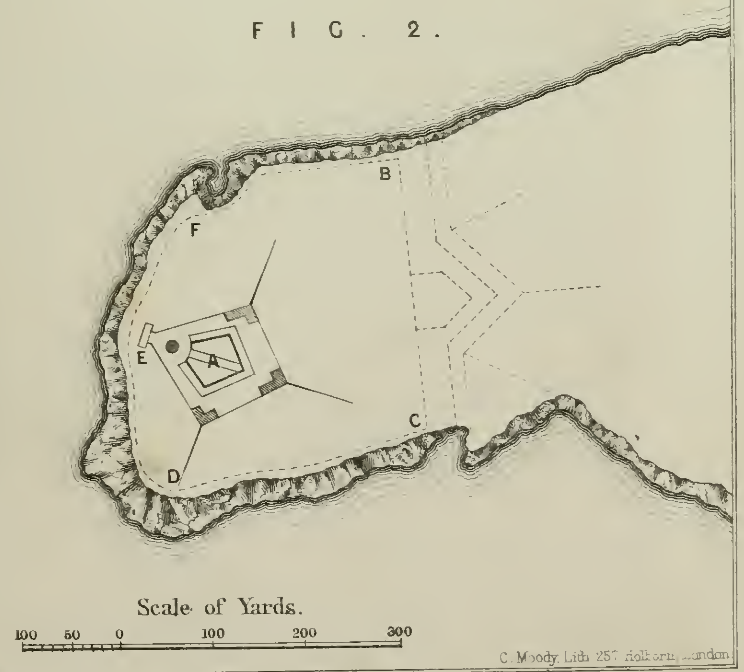


FIG. 2.



C. Moody, Lith 257 Holborn, London

PAPER IX.

FRAGMENT ON COAST DEFENCES.

By LIEUT. COLONEL NELSON, R.E.

The Question of Condensation or Dispersion of Artillery;

AND HOW TO COMBINE THE ADVANTAGES OF BOTH WITHOUT THE DISADVANTAGES OF EITHER.

In our own Corps both of these systems find experienced and able advocates.

Those for 'Condensation' consider the defects incidental to large batteries (even in two or more tiers) as more than counterbalanced by the greater convenience and power of concentrating fire on an enemy's vessel which they afford.

Those for 'Dispersion' look mainly to preserving the existence of the fire as long as possible, and they set as lightly by the mischief of comparative feebleness and unwieldiness of straggling lines as their opponents do by the liability to be suddenly and irretrievably crushed by a well directed broadside at a short distance.

So much respect is due to the ability and experience of the respective champions of these systems that we appear driven at once to the task of endeavouring to combine the merits of both plans, and to avoid as far as may be the defects of either, *i.e.*, to preserve the power of concentration, and yet maintain the existence of effective fire to the last—to avoid the liability to sudden annihilation on the one hand, (to say nothing of the accumulation of smoke in casemates by long firing, however well constructed they may be,) and the feebleness characteristic of numerous but uncombined points of operation on the other hand.

The recent experience at Cronstadt and Sebastopol has however shewn that, in *extreme* cases, the finest fleets in the world, as at present equipped, are all but powerless against well manned, yet well distributed batteries.

The system now suggested is that of a line of small dispersed turf batteries, under the control and protection of suitable towers, this line to be connected by military roads—defensible or not according to circumstances—along the rear, and the whole to be considered as only the advanced line of the local military system of defence.

Whether the line be straight, as in Fig. 1, or broken, as in Figs. 2 and 3, the system receives its fullest application along tolerably level shores, or, failing these, along even brows of hills at no great height above the water; thus

Fig. 1 shews the straight line; such as on some of our eastern and south-eastern coasts.

Fig. 2—the reentering angle, as at Cawsand Bay in Plymouth Sound, or at Brixham, Torbay.

Fig. 3—the salient angle, &c., &c.

MEMORANDA.

The longest effective range in such cases is assumed at 1,500 yards.

Two guns are assumed as being the "Artillery Element" or unit for open batteries; one gun firing (if possible) whilst the other is being loaded.

The assumed distance between the batteries, of 300 yards in Fig. 1, is obtained from the assumed number of guns (10 or 12) to be concentrated upon any point, yet still remaining under control of the towers in rear, 3,000 yards apart—each thus protecting the 1,500 yards, or half-way, on each side, the said towers being sufficiently in rear to admit of the platform-guns being depressed to see into the nearest batteries.

ARMAMENT AND GARRISON PER 3,000 YARDS.

$$\text{Artillery.}\begin{cases}\text{Tower. . }-8+\ \ 6=14.\\ \text{Batteries.}-2\times 10=20.\end{cases}$$

$$\overline{\underline{34}}=\begin{cases}24\text{ seaward.}\\ 10\text{ landward.}\end{cases}$$

Garrison. . .	20 × 3 = 60 gunners	+ 20*	. . . . =	80 gunners.
(minimum.) .	20 × 4 = 80 line	+ 40	. . . . =	120 line.
	140	+ 60 = 200 rank and file.		200
Do. ordinary.	34 × 3 = 102 gunners	+ 28*	. . . . =	130 gunners,
	34 × 4 = 136 line	+ 34	. . . . =	170 line.
	238	+ 62 = 300 rank and file.		300

The extra barrack accommodation to be provided either in the places of arms or in like enclosures round the towers.

R. J. NELSON,

28th February, 1857. Lieutenant-Colonel, R.E.

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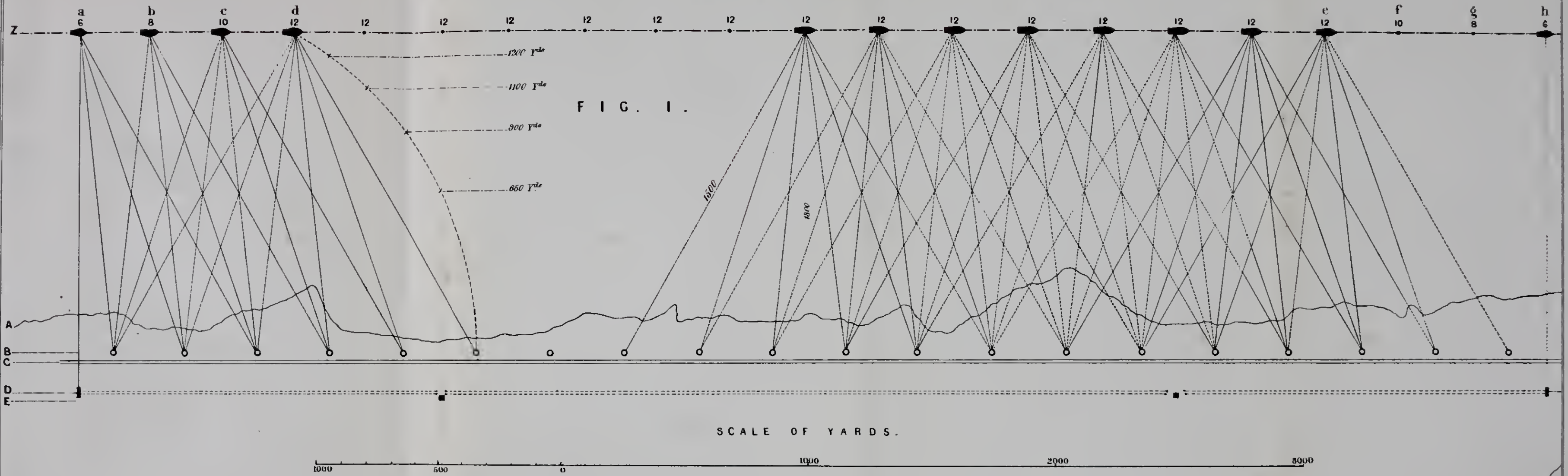
* For contingencies, and allowing a few for the tower.

NORMAL PROJECT OF COAST DEFENCE.

BY LT COLL NELSON, R.E.



REFERENCES.

A. *Coast Line nearly level or with swells not exceeding 8 or 10 feet in height; 6000 yards in length.*

Defended by B. *Line of small open earthen batteries, 2 guns each, 300 yards apart.*

Connected by C. *A Military Road along the rear with a thick hedge seaward; and Emplacements for Field Guns at suitable points.*

Supported by D. *Line of Casemated Towers, 14 Guns each (8 above & 6 below) 3000 Yards apart.*

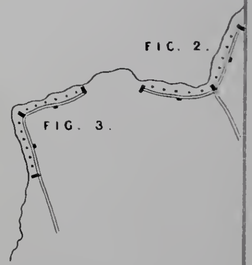
& E. *Line of intermediate Places of Arms, Musquetry Section, loopholed, and containing temporary accomodation; expense magazines &c. &c.*

Z. *The Enemy's Fleet in line at 1300 yards from the Batteries; shewing how it is exposed at every point between* d & e *(4200 yards) to a concentrated fire of 12 guns, exclusive of long shots from the 4 seaward guns in the semi circular end of each tower.*

At 1200 yards between d & e *there are 14 guns concentrated.*
1100 . . . . 16 . . .
900 . . . . 18 . .
650 . . . . 20 . .

exclusive of the fire from the towers.

From a *to* d *and from* e *to* h *the defence can only be from 6, 8, 10 guns.*



Mem. *Magazines and Stores, as well as Barrack accommodation for $\frac{1}{4}$ to $\frac{1}{6}$ the troops to be in the Towers. The Places of Arms afford immediate shelter for the Gunners, unless they join the Supporting Corps, which (as a matter of course) is not detailed: they may hold "Lean-to" accommodations, Expense Magazines, Shot Furnaces, &c. &c.*

C. Moody Lith. 257 Holborn, London

PAPER X.

NOTES ON ROAD-MAKING IN CEYLON.

By CAPTAIN SCHAW, Royal Engineers.

Having been employed under the Civil Government of Ceylon for about eighteen months in the capacity of Assistant Commissioner of Roads, and Civil Engineer in the Central Province, where I had considerable opportunities for studying the peculiar requirements of roads in tropical countries, and as the results of my experience may be useful to some of my brother officers who may have similar employment, I have been induced to draw up the following notes for insertion in the Corps Papers, if they are considered worthy of a place there.

Every country has local peculiarities of its own, which lead to slight variations in the mode of constructing and repairing its roads; but there must be a general similarity in the principles of road-making in all tropical countries, due to the similarity of their climates; and, although I have not attempted to generalize the subject, I am persuaded that the same peculiarities in road construction, which have been found necessary in Ceylon, are applicable with slight modifications to other tropical countries also.

Tracing Roads.

The principles of this operation can vary but little in different countries, but as I found, when called upon to perform the work, that I derived no assistance from books, and had several points to learn by experience, a few remarks may be useful.

In an uncultivated country, like those large tracts of the mountain zone of Ceylon which have not yet been cleared by the coffee planter, and of which no accurate maps exist, road-tracing becomes also a work of exploration, and before commencing to cut a trace through the forest between two points, I found it most necessary to walk over the ground carefully two or three times, having first, if possible, obtained a bird's-eye view of the district, or a general view of the line which the road would have to take from some of the neighbouring hills. If the road had to follow one side of a large valley, I found it of great assistance to study the features of the ground from the opposite side of the valley, observing whether it would be preferable to keep the road higher up or lower down the hill-side, so as to avoid land-slips or small spurs, and to cross the ravines, if not too deep, before they divide into smaller branches.

Having thus obtained a general idea of the ground over which the road was to be carried, I next observed with a theodolite about the angle at which it would be necessary to ascend or descend, making allowance for the increased length of road, due to the sinuosities of its course along the hill-side, when I found it comparatively easy to cut a line through the forest nearly in the best direction for the road, with the assistance of a theodolite. Whenever a piece of open " patina" or grass-land, or a projecting spur was gained, whence I could observe the point I was making for, I checked the gradient, and, if it was evident that I was too high or too low, it would be necessary to re-trace the portion of road, so as to preserve the best level, and sometimes two or three trial traces would have to be made before the best line could be marked out.

Tracing a road with a theodolite is very similar to running contour lines. I found the best mode of proceeding to be as follows: Having determined, by previous consideration, the gradient at which the road is to be traced, (1 in 20, or nearly 3°, being the steepest gradient advisable, except in special cases, for a short distance, when 1 in 15 might be allowed,) the theodolite is set up, and the level-staff sent on 15 or 20 paces, with the cross-piece adjusted to the height of the theodolite. The staff is moved up or down the hill-side as the surveyor directs, and when correctly placed, two pickets are driven in, one to mark the spot, projecting two or three feet above the ground, the other, a small picket, is driven *home*, and gives the level for the men to work to when they cut the road, the projecting one being soon knocked down or displaced. The level staff is then carried on another 18 or 20 paces, and if the hill-side does not curve, and the line remains nearly straight, or if the road is being traced level, the theodolite may be left stationary as long as the level-staff can be observed; but if the road winds round a feature, it is of course necessary to move the theodolite and re-adjust the level-staff at every picket.

A zigzag should be avoided wherever possible, but when it becomes necessary, (in order to avoid increasing the gradient to surmount a hill which cannot be got round), a precaution is required in tracing, the neglect of which causes the elbow to be inconveniently steep. In the annexed diagram, (Fig. 1), the line 1. 2, 3, 4, 5, 6, 7, represents a plan of the trace of a road on the hill-side, it is evident that if the road be cut as is shaded, there will be a very steep turn, as it would have to be cut level into the hill-side from 4 to 3, where there would be a difference in altitude of a foot. To avoid this, the piece 4, 4 (Fig. 2) should be traced level. the length of the level portion depending on the intended width of the road. The road is then cut back into the hill-side at the elbow, and the lower end of the upper portion, and the upper end of the lower portion adjusted to an easy gradient, without any part being too steep; but it is generally necessary to build a small retaining wall at the angle to support the upper portion of the road, until the distance between the two portions becomes sufficient for the earth to stand at its natural slope.

OPENING THE ROAD.

This has latterly been done chiefly by contract, £80 per mile being the average contract price for cutting a hill-side road, 16 feet wide, inclusive of the side drain.

The full width is specified to be cut out of the solid, but when the slope of the hill-side is less steep than that at which made earth will stand, it is not necessary to cut so much, as the sections will show. In Fig. 3 the prism of earth cut out of the hill-side forms the outside of the road firmly enough. In Fig. 4, the slope being more precipitous, the loose earth slips down into the ravine below, and the whole width of the road has to be cut out of the solid. Wherever made earth forms the outside of the road, and indeed in all cases, it is best to cut the road with a slight fall to the inside, cutting a small channel across at every 100 yards or so, to carry off the water; by this means the heavy rains are conducted into the proper channel, where the side drain eventually is to be cut, and the made earth is preserved from being washed away. From neglect of this precaution I have seen several miles of a newly cut road entirely torn up, and all the made earth washed away, by one night's rain; and in order to make it passable again, a sum had to be expended not less than half of what it originally cost to open the road. The contract for cutting the road generally includes removing the trees, roots, and stones which can be moved by hand, but does not include embankments, drains, retaining walls, or blasting, which latter is a separate, and sometimes very heavy item in the expense, and one which it is very difficult to estimate before hand with any degree of accuracy, the expense of blasting varying so materially with the character of the rock. Generally speaking, the harder sorts of rock are more easily fractured by blasting than the partially decomposed gneiss, which is so frequently met with just beneath the surface of the soil in Ceylon, and which yields with great difficulty to the pickaxe and crowbar, and yet is too soft and full of fissures to be easily removed by blasting. Elephants are employed with great advantage in removing trees and large boulders of stone.

Draining, and Retaining Walls.

These works are carried on simultaneously with the blasting, and it requires some judgment and experience to decide on the position and dimensions of the cross-drains. The position of the line of road must be taken into account, whether high up the hill-side or near its base, as the amount of water which must be conducted across the road depends of course on the extent of surface which the hill-side gives above the road to catch the rain. The natural water-courses are generally the best guide in this matter, and sometimes two smaller water-courses can be advantageously connected, and made to communicate with one cross-drain. Where the hill-side is steep, and the soil friable, it is a great safeguard to the road to cut a catch-water drain at about 10 to 12 paces from the edge of the bank above the road to conduct the rain-water into the cross-drains. Unless these catch-water drains be cut, the rain-water from the hill-side above pours down the bank and causes frequent land slips, which choke up the side drain of the road, when all the water finds its way on to the surface of the road itself, tears up the metalling, and does untold mischief. Cross-drains in hill side roads in Ceylon are necessary, on an average, at about every 150 yards, and vary in size from 1′ 6″ × 1′ 6″ to 1′ 6″ × 2′ 0″ high. They are built generally of dry stone work, there being usually an abundance of large flat stones suitable for forming the bottom and covering stones of the drain. The fall given to the drain is about 1 in 20, (Fig. 5). The cost of such a drain is usually £2 12s. where stone is plentiful and elephant labor is employed. Retaining walls are usually built of dry stone work, which costs about 4s. 6d. per cubic yard. The execution of this class of work by the Ceylon Pioneer Corps, with the assistance of elephants, cannot be excelled. Wherever a watercourse has hollowed the hill-side, a cross-drain and retaining walls are usually built, to carry the road across in a straight line. Where the rock is exposed on the hill-side it is generally cheaper to build a retaining wall on the outside, and blast away only half the road out of the rock, than to procure the whole width by blasting. A level footing has of course to be formed for the wall first. (Fig 6.)

The retaining walls and cross drains being built, and all rock blasted clear away, and the side drains cut and blasted out where necessary, the road is fit for light traffic in dry weather; and where the soil is disintegrated quartz-rock with veins of felspar, forming an excellent gravel, the road is often left in this state and answers the purposes of a small district sufficiently well; but where the traffic is at all considerable, or the soil clayey, it becomes necessary to gravel or metal the road. The former material is much the cheaper covering, and though it requires more frequent repair, being continually injured by the heavy rains, and cut up by cart-wheels, yet where it is procurable within two or three miles it is the best material for minor roads.

The trunk roads, however, and the minor ones in those districts where the gravel is not procurable, have to be regularly metalled with broken stone.

SYSTEM OF METALLING.

Metalled roads in Ceylon are formed and kept up on a different principle from that pursued in England for several reasons. The traffic is chiefly that of the native bullock-carts, carrying about one ton on two narrow-tired wheels, and drawn by a pair of bullocks.

These carts travel chiefly by night, and follow one another in a long string ; and the wheels following exactly in the track of the bullocks the result is that the road is inevitably worked into two deep ruts, unless it is of such a width and even surface, and the traffic is so general, that the bullocks have no inducement to adhere to the same track.

The tender nature of the bullocks' hoofs makes it necessary that the roads should be smooth before they can work on them.

The climate constitutes another reason for the method of road-making peculiar to Ceylon.

There is hardly ever any weather suitable for the repair of roads by picking up the surface, and simply laying on a fresh coating of material. Either the sun shines with full tropical intensity, and dries up the road so completely that the new material remains loose and will not bind, or else it rains as it only *can* in the tropics, and if the stone be lying loose on the road it is swept away into the side drain and washed over the precipice on the edge of which the road is probably formed. The experience of these difficulties has led to the adoption of the following system, which cannot perhaps be improved under the circumstances. When the road is in the state described under the last heading, (and while it is being brought to that state, if the men be available) broken stone is prepared in the nearest quarries, carted to the road and piled in a regular heap along one side, in the quantity in which it has been determined to spread it on the road. When the road is to be metalled to a width of 14 feet, (the usual width for minor roads) the quantity of metal varies from 14 to 12 *heaped* bushels per yard lineal.

A piling-iron is used to ensure the correct section being given to the heap. Binding gravel in the proportion of about 4 bushels per yard lined for a 14-feet road is also prepared and carted to the spot. Dry weather is chosen, if possible, for metalling a new road, as the subsoil is then firm and hard. The metal is spread by a metalling party of from 20 to 25 men, who first bring the bed of the road to a proper shape with desintegrated stone, or any such material that can be cut out of the bank close at hand, and which is rammed solid.

On the minor roads, the peculiar nature of the traffic, (working altogether in two ruts) led me to adopt the section shewn in Fig. 7, so as to give the greatest thickness of metal where it was most required. The bed of the road being prepared a little in advance, 2 men follow and drive level pickets to guide the spreading of the stone, a road-level being used for the purpose. The best "barrel" for a road has been a subject of much discussion, and of numerous experiments. The following facts have been established 1. A greater degree of barrelling is necessary on a steep gradient than on a level, in order to turn the water into the side drains, instead of letting it course down the road and cut it into channels. This, it will be observed, is opposed to the practice in England, where the drainage of the road may be secured by means of the gradient. In the tropics, if the rain-water be allowed to run down the road instead of being conducted at once into the side drain, it soon converts a minute rut into a large water-course.—2. More barrel is required on a 14-ft. road than on a 20-ft. road, as the traffic on the former, whether its section be nearly flat or much barrelled, will alike be confined to the centre of the road; while on the latter, if not prevented by an excess of barrel, the traffic will be more evenly distributed. — 3. For a 14-ft. road the best barrel, where the gradient is steep, is procured by the arc of a circle whose radius is 60 ft. Where the road is nearly level the radius should be increased to 70 ft. —4. For a 20-ft. road the best form of section has been found to be two slopes of 1 in 20 connected by an arc of a circle of 60 feet radius, where the road is level. When it is carried on a steep gradient, the side slopes of the cross section are increased to 1 in 15. The metal is first spread evenly on the ground with the proper barrel, as shewn by the pickets previously fixed, and the metalling party consolidate the mass of stone with wooden rammers; a thin layer of gravel is then spread over the metal, and it is well watered by hand (the water being thrown from buckets, which has been found better and cheaper than watering carts) and it is then rammed again.

A second coat of gravel, watered and beaten a third time, is generally employed to bring the road to a perfectly solid and even condition.

The first carts that pass over it may leave some impression in places where from some cause a slight settlement takes place, and the rut is immediately filled with fine broken stone, watered, gravelled and rammed. The operation of metalling in this manner costs about 8d. per yard lineal for a 14-ft. road, or 10d. per yard lineal for a 20-ft. road.

I tried the system of rolling the road, in order to consolidate it, with heavy rollers drawn by elephants, instead of using the wooden rammers; and where the road was moderately straight the rolling answered admirably, not only being quicker and cheaper, but more effectually compressing the metal; but when the course of the road was tortuous the roller was not so satisfactory, as the twisting motion at the turns of the road tore up the metal. The assistance of a few rammers was always necessary to finish the sides of the road, and bring it to a completely even surface. (Fig. 8.) The roller used was a double one, roughly constructed out of the trunk of a large tree, sawn across and cased with sheet iron. A wooden framework, supported upon the axes of the rollers and planked over, served to carry large stones as a weight to give them more effect. The shafts were secured by means of a strong hook and eye, and were made to shift from front to rear of the roller, to avoid the necessity for turning it. The length of each cylinder was about 4 feet, and the diameter 2 ft. 9 in. The weight when fully loaded was about 3½ tons. It had to be passed over each portion of the road several times before it was fully consolidated. A heavier roller with cylinders of larger diameter would have been better. Some nicety was necessary in proportioning the quantity of water used, so as to prevent the gravel and metal adhering to the roller, and being lifted up with it. The sides of the road are usually preserved by an edging of turf, but where stone can be employed and grass kept away, it is preferable, as the grass prevents the water from running into the side drains. The coating of broken stone used on Ceylon roads is not more than 6 inches in thickness, but when carefully laid and consolidated at first, it lasts, if carefully kept up, for 5 years on the Colombo and Kandy trunk road, which has a traffic of 59,000 carts per annum, (150 to 200 carts per diem) exclusive of horses and light vehicles. The cost of keeping up this road is about £11,000 per annum, and its length is 72 miles; but the stone used is most carefully selected and is of first-rate quality. Whenever the surface of the road becomes uneven, either from the effects of traffic or of the rains, the ruts are picked up and filled with finely broken stone, which is gravelled, watered, and rammed into a solid mass again, and this system of patching and partial repairs is carried on until the whole coating is worn so thin that it becomes necessary to renew it, when the metal is prepared and piled beside the road, and the surface having been picked up, it is re-coated in the same manner as at first described. The length of time that this coating lasts depends on the quality of the stone, the amount of traffic, and the attention paid to the clearing of side drains, and filling of ruts, &c., during the whole of the time that intervenes between the grand renewals.

The system of "mile-men" does not, I think, answer so well as that of "flying parties" sent over a line of road, just before the change of monsoon, when the rains may be expected, and who clear out all the drains, and make any small repairs that may be necessary.

The trunk-roads are under the charge of officers, who have systems differing in some degree, for carrying out the repairs, but in general a superintendent is put in charge of 6 miles or so, with a small party of men, and he employs them at whatever portion of the road he finds most in want of repair.

Stone and gravel for repairs are always kept in depôts at short intervals all along the road.

Materials.

The best stone for roads found in Ceylon is a compact gneissic rock, of a fleshy color, highly crystalline, and composed almost entirely of felspar and quartz.

Hornblende rock, or a variety of gneiss in which hornblende and quartz predominate, and felspar and mica are almost absent, is very hard, and makes excellent road metal, but it does not bind so readily as the felspattic rock. These rocks are found in most parts of Ceylon, the felspar variety being most usual in the hills, and the hornblende rock in the low country; but in some districts mica predominates, and then road-making is most disheartening work, and it is cheaper to transport good stone for almost any distance, or to use quartz gravel, if it can be found, than to employ the micaceous gneiss as road-metal, for it crumbles into dust in dry weather, and disappears in mud during the rains. Careful searching for better stone is however usually rewarded by the discovery of quarries of good quality even in what appear the worst districts, as veins of felspar and quartz are often found in the micaceous rock; and the delight with which a good quarry is hailed, after a wearying search of many days through a tropical jungle, can only be understood by a road-maker. A blinding of gravel is, as was mentioned above, universally employed in metalling in Ceylon. The best material found there for the purpose is a red gravel resulting from the disintegration of the quartz and felspar rock. The felspar is changed to fine clay, and the crystals of quartz are thus separated, and the mass can be cut with the "mamotie" (a large heavy hoe used throughout India instead of the spade). There are many varieties of this rock in which the crystals of quartz are large and the quantity of felspar small; this makes a fair road-material in itself when the traffic is not heavy. The larger blocks of quartz are broken with a hammer, and the road being formed with the broken quartz, the finer gravel is used for binding.

Some nicety is required in the selection of the gravel; if too fine, and free from clay, it turns to dust, and does not bind, and if too much clay be present it makes the road muddy, and in wet weather the wheels lift up the metal which adheres to them. In the low country where this material is not to be found, "cabook" gravel is used. The cabook or laterite of Southern India is a very singular formation. On the surface of the ground a hard red gravel appears, and beneath it a compact rock, mottled yellow, white, and red, of a cheesy consistency, so that it can be readily cut out in blocks which are extensively used for building purposes, the blocks being of the dimensions 18″ × 9″ × 6″.

This rock hardens by exposure, but it is injured by heavy rain, and has to be protected by plaster.

Much discussion has taken place as to the origin and character of this rock, and the opinion of those most competent to decide the question is that the gneiss rock has undergone decomposition, owing to the presence of iron in the two forms of peroxide and protoxide ; but, be this as it may, the gravel is most important to road-makers, and is employed both for forming minor roads and blinding the metal on the more important ones. It is generally necessary to screen this gravel before using it, to separate a portion of the clay.

QUARRYING.

The stone for road-making or building purposes in Ceylon has to be procured almost invariably by blasting. The stone being exceedingly hard, and the miners in general not so powerful, physically, as Englishmen, the mode of blasting is somewhat peculiar. The jumper, properly so called, is never used, the native workmen being unable to wield it to advantage ; the borer and hammer are the universal miner's tools. The borers found most serviceable are formed out of 1¼-inch bolt iron. The miner's hammer weighs from 5 to 7 lbs., and a trained miner bores from 36 to 40 inches in the hard gneiss rock per diem, using each hand alternately to wield the hammer and turn the borer.

Water is used to facilitate the operation, and a small band of straw, put round the borer, prevents the mud from being jerked up into the miner's face. Tamping is performed with small fragments of soft rock, a wad of straw being always inserted into the hole below the powder and another placed over it, before the tamping is commenced. The charges are fired by Bickford's fuze. The gneiss rock is generally so intersected with cracks that large charges of powder do not produce the effect that might be expected, and small holes, 18 inches in depth, loaded with about ⅙th lb. of powder are found most effective. The rough rule of the native loaders is to fill the hole with powder to a depth in inches corresponding to the whole depth of the hole in feet, thus a hole 18 inches (1½ ft.) in depth would be loaded with 1½ inches of powder. This rule of course is only applicable to holes formed with the 1¼-inch bit, and is sufficiently accurate, though the harder and more brittle rocks require less powder than the softer and tougher sorts.

A trained Pioneer sledges, collects, and breaks into road-metal 9 or 10 heaped bushels of stone in a day (a cube of 1¼ inch each side being the average size of the pieces), he also carries the stone he has broken to the heap, when it is measured by the Corporal or Superintendent in charge of the party. A proportion of 1 miner to 5 stone-breakers is usually sufficient, but 1 to 3 is sometimes necessary in different quarries. The cost of broken stone for road-metal in Ceylon is usually 2¼d. per bushel (heaped) to which the cost of transport must be added, which gives an average of 2¾d. per bushel for the metal ready piled along the road-side. This price includes the pay of workmen and superintendence, and the cost of powder and fuze, and also materials for making and sharpening the borers, but does not include the value of tools and plant. The following is the usual estimate of materials for 10 bushels of metal, viz. :

Powder	1¾	oz.
Iron	11	oz.
Steel	1½	oz.
Fuze	1	foot.

LABOUR.

Immigrant Coolies from the coast of India supply almost the whole of the labour in Ceylon. Of these a most efficient Corps of Pioneers has been formed by Government for carrying out the public works of the colony.

Four divisions of Pioneers are kept up and paid on the fixed establishment of the island, and four sub-divisions have also been raised to meet the demand for skilled labour. The organization of a division of Pioneers is as follows:—

1	Division Officer	at £250	per annum.	
1	Clerk	at £40	do.	
1	Serjeant Major	at 2s.	per diem	(Sundays included).
3	Serjeants	at 1s. 4d.	do.	do.
3	Corporals	at 1s. 2d.	do.	do.
3	1st Class Artificers	at 1s. 6d.	do.	do.
3	2nd Class Artificers	at 1s. 3d.	do.	do.
4	3rd Class Artificers	at 1s.	do.	do.
12	4th Class Artificers	at 9d.	do.	do.
104	1st Class Pioneers	at 7½d.	do.	do.
50	2nd Class Pioneers	at 6d.	do.	do.
10	Boys	at 4½d.	do.	do.
Total . . 195				
50	Women	at 1d.	do.	do.

Pioneers are enlisted for a term of years, and though their pay is higher than that of ordinary labourers, yet the work performed by each man is so much superior both in quality and quantity to that of an untrained Cooly, that pioneer work has been found to be in every way the most economical. The difficulty also of procuring labour when required, more especially for opening roads in remote parts of the country, is so great that the Pioneer Corps has been invaluable to Ceylon.

When a new road has to be opened, or an old one thoroughly repaired, it becomes necessary to provide lodgings for a division of pioneers, with a gang of coolies to work with them if possible. The usual method is to build a set of sheds with jungle-sticks, thatched with jungle-grass, near the centre of the portion of the road to be worked on. Three miles is considered as the maximum distance from his lines which a pioneer should be required to walk to his work, and if it is less, the work must of course proceed more rapidly, and without the same distress to the men. A set of 'lines' sufficient for the accommodation of a division of pioneers, with a bungalow for the division officer, clerk's house, serjeant-major's house, an office and store, cost usually £70; which sum must be added to the estimated cost of the repair or opening of every five or six miles of road. The lines for a division are usually built so as to form three sides of a square, with perhaps one or two additional sheds in the centre. The men lie on mats, or build small dais for themselves with jungle sticks.

The division officers are frequently officers of the Ceylon Rifles, or of some Queen's regiment serving in Ceylon, who are allowed to take the appointment; the salary for a military officer is about £100 per annum, in addition to his pay, with forage for a horse.

The artificers are chiefly masons and bricklayers, with two blacksmiths and two carpenters to each division. The women at 1d. per diem represent a boon called "family allowance," given to deserving married men. The boys usually enlist in the corps, and by early training become most expert workmen.

ROADS IN CEYLON.

FIG. 1.

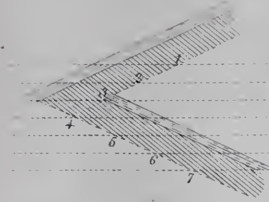


FIG. 2.

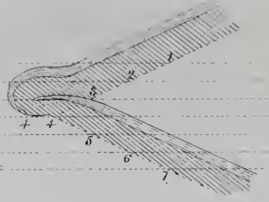


FIG. 5.

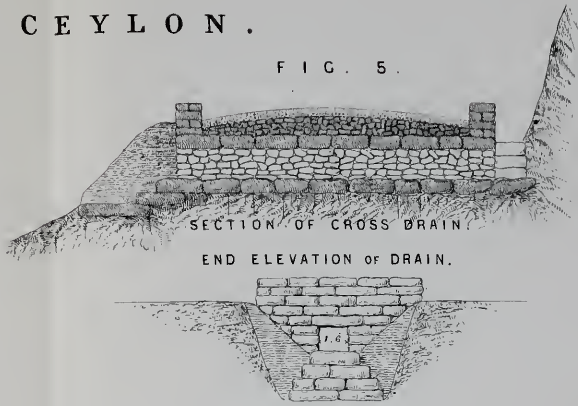


FIG. 3.

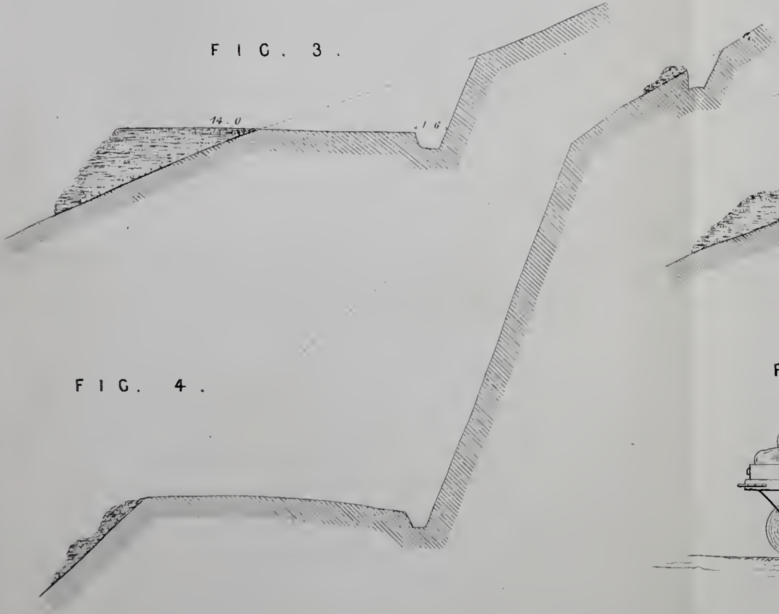


FIG. 6.

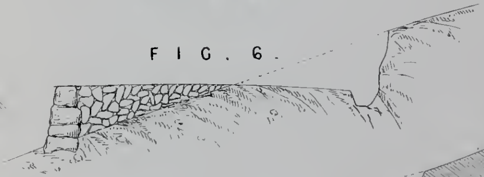
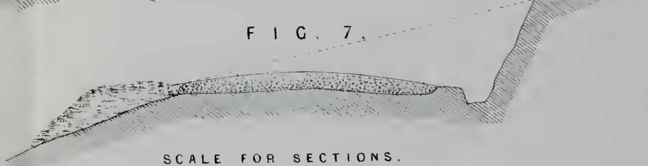


FIG. 7.

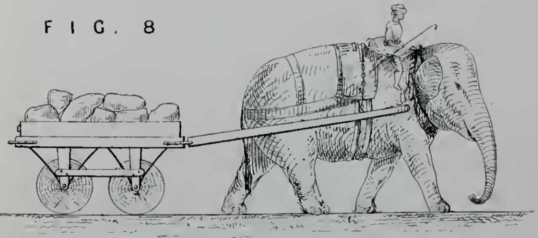


SCALE FOR SECTIONS.

1/8th Inch to a Foot.

FIG. 4.

FIG. 8



C. Moody, Lith. 257 Holborn London.

The organization of the sub-divisions is similar, only that their total strength is 127 instead of 195, and that they have no division officer, clerk, or serjeant-major, but a native officer in lieu of them.

In this summary of the method of road-making in Ceylon, I have not alluded much to the low country, where the forest extends for many miles over a nearly level plain, with no elevation whence a general view of the country can be obtained, and here new roads have frequently to be traced by compass.

Embankments are often required for considerable distances in districts liable to be flooded by the rising of rivers during the rains, and great care is necessary to leave sufficient openings in the embankments for the free passage of the water.

The subject of bridges does not belong to this paper; but I may remark that in new roads of secondary importance timber trusses, supported on masonry abutments, are usually employed, the king or queen posts being left long enough to form the supports of a roof. And when it is contemplated to build an arch eventually, the abutments are built with a view to be able to resist the thrust. If the timber is well seasoned, and protected by a roof, it lasts from 20 to 30 years, and even longer.

In opening up a new country it is generally an object to obtain roads as quickly and cheaply as possible. The preliminary surveys are therefore seldom conducted with any great accuracy. One soon becomes able to judge very nearly what is likely to be met with in cuttings from the appearance of the surface, and each mile of road is estimated for approximately, taking into consideration the amount of cutting and blasting, the dimensions of the necessary embankments, retaining walls, drains, bridges, &c., and also the distance from which stone and gravel must be transported. The highest average cost of opening a 14 ft. road in the hill country of Ceylon, with drains, retaining walls, embankments, &c. is £400 per mile, and metalling costs about £250 per mile additional. This estimate does not of course include bridges, which must form an ever-varying item.

H. SCHAW,

Captain R.E.

Chatham, 12th Nov., 1856.

PAPER XI.

JOURNAL OF THE OPERATIONS OF THE EXPEDITION TO KINBURN, IN OCTOBER, 1855,

BY LIEUT.-COLONEL BENT, R.E.

AND REPORT ON ITS DEFENCES, AND ON THE OPERATIONS WHICH LED TO THEIR SURRENDER,

BY MAJOR NICHOLSON, R.E.

JOURNAL OF THE OPERATIONS OF THE EXPEDITION TO KINBURN, UNDER BRIGADIER-GENERAL THE HON. A. SPENCER,

BY LIEUT.-COLONEL BENT, R.E.

OCTOBER 14th, 1855.—The fleets weighed anchor at sunrise, and steamed out of the Bay of Odessa, following the flag ships.

	Ships of the Line.	Frigates and Corvettes	Floating Batteries	Gun Boats.	Mortar Boats.	Transports	
English.	6	14	0	13	6	12	
French.	4	9	3	9	0	4	
	10	23	3	22	6	16	Total.—80.

We kept close along shore the whole way and arrived off Kinburn soon after 1 P.M., but as arrangements had to be made for buoying out the deep water channel, it was determined not to land until the following morning.

OCTOBER 15TH.—The troops were put into flats and paddle-box boats, and towed 3 miles below the forts by small steamers; the landing-place[*] was flanked by gun-boats, we landed without opposition, and as soon as a sufficient number (two or three companies) were assembled they were thrown out in skirmishing order and occupied the broken ground in our front, and gradually, as supports formed up, the skirmishers extended across the neck of the land from sea to sea, facing towards the main land. By the time this was done the French arrived in boats, and in a similar manner advanced a cordon of troops, cutting off the neck of land and facing Fort Kinburn.

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[*] See Plate I.

I accompanied the French general in his reconnaissance towards the fort, to learn in what manner he wished to post the troops, and throw up entrenchments; and then returned and rode over the ground with General Spencer: it consists of a narrow strip, about 1½ miles across, of sand sufficiently irregular and broken on the surface by undulations and depressions to afford the choice of a defensible position; that selected enabled some regiments to be posted on salient hillocks which gave a flanking fire to the others, whilst the whole of the force was concealed from view by their situation on the reverse of the slopes.

In company with the French Engineer, I agreed upon and partly traced a work to defend the landing-place, which also served as a "keep" to the rest of the fortifications.

At night, each regiment gave working parties and entrenched the positions in front of their several camps, under the directions of the officers of Royal Engineers and the Royal Sappers and Miners.

October 16th.—Working parties were employed all day strengthening the entrenchment and throwing up two outworks to protect the right of our position.

The sea was too rough for boats to land.

October 17th.—We continued to strengthen the position, which now assumed a very respectable aspect.

We were employed sinking wells in the sand, and found good water everywhere at a depth averaging 7 feet.

The sea is not too salt for washing, and soap lathers in it quickly. Horses will not drink on the south beach, but do so along the north side, where the water is fresher from the confluence of the Boug and Dnieper rivers in the bay.

October 18th.—The weather was propitious for the fleet, so in the course of the morning they moved into position against the fort. The French floating batteries and the gun-boats anchored at a distance of 700 yards from it, many of the line of battle ships at 1,200 yards, and others further off, each one opening fire as she came up: several frigates, corvettes and gun-boats had gone (the night before) into the bay, and raked the batteries from the north side. The fire was so tremendous that the Russians were silenced by about 1 p.m., and a flag of truce was sent in from the fleet to offer terms of surrender: this was speedily arranged and the garrison marched out with the honours of war; the officers retained their swords, but the men laid down their arms on the glacis; they were allowed to take away all personal and church property. The strength of the garrison was estimated at about 1,200, of whom 60 were killed or wounded.

October 19th.—A commission of French and English officers were assembled in the fort to take account of its state and of the munitions of war left in it. I attended as Commanding Royal Engineer.

After consultation with the French Commander-in-Chief and his Commandant-du-Génie, it was agreed that the French should give attention to the reform of the fortifications, mounting the guns, &c., and that the English should try to restore the barrack buildings and render them fit for occupation by troops in the winter.

The description we had previously received of the Fort was accurate enough, except that the casemates were not armed throughout, the majority of them being used for provision stores and barrack accommodation.

A large two-storied block of buildings in the interior of the fort was about half burnt down (set on fire by our shells), and the remaining houses were rendered uninhabitable by the injury received from shot passing through the walls, roofs, &c.

The ramparts were old and easily breached by the floating batteries; had the fire from the latter continued much longer two practicable breaches would have been formed; nearly every one of the guns mounted "en barbette" were destroyed, or had their carriages broken and disabled.

The two sand batteries (see Plates 1 and 2) near the head of the spit resisted the fire much better than the *old* masonry fort; they were perfect in construction—masterpieces of workmanship. That nearest to the extremity was formed of "cribwork," viz., trunks of trees, notched and fitted together, with the intervals filled with sand and sea shells. The guns and gunners were protected in casemates, solidly formed of massive timber, and crowned with sand and sods. The parapet was likewise formed of sand, revetted inside with hurdles and gabions, and outside with sods. This work was still in progress; it was pierced for 19 guns, but 9 only were mounted. It was provided with a shot furnace.

The other battery had all its guns mounted "en barbette;" the parapet was built of sand and thickly revetted with sods. A bomb-proof block-house filled the interior space of this work and afforded a barrack for the defenders.

So perfect in construction were these two batteries, or rather redoubts, that I am of opinion that had the expedition been delayed another week, and time been given to the Russians to finish them, they would have proved most serious obstacles to the passage of the ships, and might almost have beaten them off.

The Admirals and Generals agreed to retire the whole force to within 1,200 yards of the fort, and take up an alignment protected by the fire of the guns of the fleet.

October 20th.—We moved our encampment, which occupied all day, owing to deficient land transport.

October 21st.—The Generals determined to make a reconnaissance in force to ascertain what was in our front. The troops marched out 6,000 strong, taking six days' rations with them.

Lieut. Gordon, R.E., accompanied this reconnaissance to sketch the ground.

The French sent a battalion into the fort, and the English left a battalion and two field guns to guard the camp.

I found myself in orders to command the troops in camp as senior officer.

We gave principal attention to-day to sinking wells, but the water had all a brackish taste; it however served for drinking and cooking for want of better.

October 22nd.—A working party of 100 men assisted the Sappers in repairing the barrack buildings in the fort only till 10 a.m., it being Sunday.

October 23rd.—Parties were employed all day in the fort.

GEORGE BENT,

Major Royal Engineers.

REPORT ON THE DEFENCES OF KINBURN AND ON THE OPERATIONS WHICH LED TO THEIR SURRENDER, OCTOBER, 1855.

BY MAJOR NICHOLSON, R.E.

The Allied forces landed on Kinburn Point on the 15th October, 1855, for the purpose of preventing any attempt which might be made by the Russian forces to relieve the garrison of the fort situated on it, and also to stop the garrison should they endeavour to retreat, the intention being to bombard the fort from the fleet, and force it to surrender.

The Allied forces consisted of about 5,000 British and about 3,500 French, but as the spot at the point of landing is about 2 miles in width, and devoid of any natural features which could enable so small a force to hold it against superior numbers, it became necessary to entrench their position. On the same night therefore three or four portions of an intrenchment were commenced on the left and centre of the line, and on the right a work was traced by the British Engineers and commenced by a French working party, which, being complete in itself, was intended to enable the troops driven in from other points to hold till the last a portion of the beach, from which they could embark in case of urgent necessity. This work was in the form of a horn-work, and having its two salients on two sand-hills, and its flanks resting upon the sea, it became not only a very strong position to hold in case of any reverse, but also an excellent point on which to rest the intrenched line above alluded to.

The line of intrenchment was traced so that the gun-boats could sweep its front from right to left, and it was with some difficulty, owing to the shape of the sand-hills, that this condition could be fulfilled. In front of it also were small lakes or marshes, and the line was laid out so as to take advantage of these natural obstacles in the way of an advancing force.

The portions commenced with these objects in view, during the first night after landing, were on the following day connected, and, as far as the form of the ground would admit, the indented trace was adhered to as much as possible, whilst any broken ground in the line of defences was in every instance taken advantage of, and connected with the main line.

On the 2nd day all the different portions were connected, and on the left the line assumed the form of a small lunette in which it was intended to mount some guns of position, whilst the right of the line was joined to the salient of the horn-work.

Two small detached works were also thrown up on some prominent sand-hills in front of the right of the position; these were intended to be defended by the outlying pickets, to hold an advancing enemy in check and flank the whole front of the main line.

The camps of the different regiments were in rear of the entrenched line, and were so disposed as to be almost hidden by the sand-hills in their front; and it was arranged that the parapet in front of each regiment was thrown up by that regiment, so that each felt an interest in the speedy completion of the trench which was to form their own principal defence.

The trench was completed on the 17th October, and was made about 6 feet broad and 3 feet deep, with a banquette 3 feet broad, the earth thrown to the front forming good cover for a man kneeling on the banquette; but it was intended ultimately to widen and deepen the trench, and, throwing the earth to the rear, to form it into a good parapet, whilst the earth already in front of the ditch would then become the glacis, but on the morning of the 17th October the bombardment of the fort was commenced by the Allied fleets, and, as it ended in its surrender, it was considered advisable to relinquish the entrenched line and retire the forces to the village under the guns of the fort, and thus greatly to contract the line of defences. It was a great advantage that the ground close to the fort was perfectly flat, so that every portion of it was open to the fire of the gun-boats, which were able at this point to advance within 900 yards of the shore. In addition to the entrenched line above-mentioned the French commenced a second line in rear of the left, which they intended ultimately to connect with the left salient of the horn-work, thus completing two lines of defence across the spit.

Before the bombardment took place, as it seemed uncertain whether the vessels would be able to come in on account of the weather, it was considered advisable to commence the siege of the fort by land, and on the night of the 16th the French opened the 1st parallel at an average distance of 900 yards from the fort, an agreement being entered into that all the working parties were to be supplied by the French, but that the British Engineers were to take their turn of duty in the trenches with the French Engineers: the immediate success of the bombardment however put a stop to these proceedings.

The bombardment of the fort commenced about 6 A.M. on the morning of the 17th, by the mortar-boats, floating batteries and gun-boats taking up their positions at distances varying from 700 to 1,000 yards from the fort, and opening a heavy fire of round shot and shells; they immediately set on fire one of the barracks in the interior, and in a very short time the fire from the French floating batteries reduced to ruins a portion of the stone escarp of the Southern and land fronts, but it was observed that scarcely any of the guns on those fronts were silenced until the fire from the larger vessels commenced.

A portion of the gun-boats directed their fire on the small works on the spit, but either the latter were insufficiently manned or the gunners would not fight their guns, for but few rounds were fired from them, and though it was thought that these batteries would cause the greatest difficulty, they offered but slight impediment to the ships rounding the point to take up their position to the north of the spit, so as to obtain a cross-fire upon all parts of it. As soon however as the flying squadron of steamers and one or two of the two-deckers had taken up their position on the northern side of the fort, the remainder of the two-deckers and the two three-deckers, carrying the respective flags of the British and French admirals, approached to within 1,200 yards of the fort on the western side; then commenced the most terrific fire on all points; and it was at once evident that, not only were most of the guns silenced, but that the gunners in the fort could not stand to their guns; in the mean time the fire raged in the interior, and the southern face and a portion of the land-front seemed to have become a perfect ruin, so after this fire had lasted about 2 hours from the larger ships flags of truce were run up to the mast-heads of the admiral's ships, and the signal was made to cease firing: boats were then sent in to parley, and it was finally agreed, on the part of the Russian governor, to surrender the fort at discretion, the garrison marching out prisoners of war.

Description of the Defences.

The defences of the spit consisted of the large fort, which mounted about 60 guns, and two small detached works, between the principal one and the end of the spit, mounting respectively 11 and 9 guns.

The principal fort is a quadrangular work, two faces being parallel to the east and west shores of the spit, and the remaining two faces being directed respectively towards the main-land and the point of the spit.

This fort is surrounded by a stone escarp varying in height from 12 to 20 feet, with an earthen parapet about 15 feet in width. The sea faces are casemated, but little use seems to have been made of them for purposes of defence, only about 6 guns having been mounted in them altogether, some of the embrasures being bricked up, and many of the casemates being filled with stores and provisions.

The casemates themselves, however, were exceedingly well formed, and the ventilation of them, where there were any guns, was very good; but in instances where the casemates had been converted into stores the rear had been closed by a wooden partition. They were all completely bomb-proof, and the embrasures were placed about 23 feet from centre to centre; piers 6 feet thick supported semi-circular arches, the springing lines of which were about 6 feet 6 inches above the floors: all the casemates in use were fitted with platforms about 2 inches above the ground, the guns being mounted upon traversing platforms and firing over a "genouillère" about 2 feet in height.

The land-front is composed of three bastions of irregular trace, and of different sizes, the curtains between the northern and central bastions being broken into two lines forming an angle, the flank of each bastion being at right angles to that portion of the curtain contiguous to it. The curtain between the central bastion of this front and the southern bastion, which is the left bastion of the sea-front, is perfectly straight and well flanked.

The sea-front and that towards the end of the spit are formed with a simple rampart, the outside having a perpendicular escarp, about 12 feet high, and the inside being revetted in a similar way; the approach to the terreplein is by ramps, and the parapet is formed of earth about 15 feet thick, with a sodded exterior slope and an interior slope revetted with stone.

The north face of the land-front is connected by a long flank with a high casemated work in the form of a redan, the parapet of which is raised considerably above the terreplein of the contiguous works, whilst its casemates flank the escarp, and this would assume the importance of an interior retrenchment in case an enemy should attempt to mount the ramparts to its right and left. Had the casemates in it been found to answer, it would have proved the most formidable defence of the north-east front, but, as before observed, the embrasures had been walled up, and its power of opening a flanking fire on the escarp to its right and left was in consequence greatly reduced.

On the north-west side of the fort there is a regular front of fortification, which is connected with the before mentioned casemated work by the flank of its northern bastion; but the whole of this front is of similar section to that of the land-front, and the terreplein is therefore very much below that of the "redan." Its flank defence is exceedingly good; the flanks are curved, and the ends of the curtain are slightly thrown back to meet them. The escarp of this front is about 12 feet high, but the number of guns mounted on its terreplein was very insignificant.

The left face of the southern bastion of this front forms one end of the line of defences on the sea side of the fort, which is built close to the water's edge, and has an escarp about 20 feet high, entirely casemated from end to end, the casemates being designed to afford flank defence; but as the casemates have not been used, nor had a single gun mounted in them, the flank defence of this front becomes a mere bagatelle. In the centre of it is a small bastion, and the line between this and the western extremity of the front is broken into a small flank to protect the angle of the western bastion.

Both the land and the north-west fronts of the fort are provided with wide but shallow ditches and cunettes, but the counterscarp is so low as to be unworthy of notice, and the defence of the outer edge of the ditch has been allowed to depend on a covered way of low profile; but the salient angles have been filled in, and are constructed for guns en barbette, though in only one or two instances have guns been mounted there.

The entrances to the fort are in the land and north-west fronts, and are approached across the cunette by permanent wooden bridges with draw-bridges of antique construction close to the escarp; both these entrances, as well as the sallyport in the east front, are well protected by very strong stoccade defences.

The interior space of the fort is taken up by extensive barracks for the accommodation of 1,500 men: the rooms are large and airy, well warmed, and of good design generally; but the stone-work of these buildings, and also of the defences, is of the worst description; for this reason the rapidity of their destruction produced by the ships' fire cannot be taken as a criterion of the power of a ship's broadside against stone walls; but on the other hand, with respect to the effect of shot on the floating-batteries, for the first time made use of on this occasion, it is worthy of record that one of them was struck 64 times by round shot from the fort, but that the greater proportion of them fell harmless into the sea, and only one made an indentation of 2 inches in depth in the wrought iron plates with which they are covered.

There were found in the fort 9 mortars of different calibres, with a very tolerable store of ammunition, but the parapets were remarkably short of guns, whole faces being without a single gun, and, unlike the batteries at Sebastopol, little attempt had been made to traverse those guns which were mounted.

The powder magazines were exceedingly well formed, with stone arches and buttresses, the tops being well protected with earth, and, as a last attempt to make them quite safe, the Russians had covered them with the spare trucks of the gun carriages and traversing platforms.

The two detached works which complete the defences of the spit are situated respectively at the distances of 1,400 yards and 3,300 yards from the fort. The spit is 370 yards wide close to the fort, but it gradually becomes narrower, until at the place where the outer work is situated it is only 140 yards in width.

The latter is of an oblong form (see Plate 2), and its guns are mounted in casemates of a novel construction on the face towards the channel between the spit and the main land, but the other face is merely a high embankment revetted with gabions for musketry defence.

The casemates are constructed with heavy timbers 1 foot 6 inches square, laid across immense uprights 1 foot 6 inches in diameter, which supply the place of stone piers where the casemates are formed with arches; these uprights, therefore, are placed on either side of each embrasure and gun, and across the horizontal timbers which they support are laid two thicknesses of timber 1 foot square, and one layer of boarding 2 inches thick, with overlapping joints; on this planking is placed sand, about 6 feet in thickness, its slopes being well revetted with sods cut from the salt marshes on the spit.

The merlons, genouillères, cheeks, sills and lintels of the embrasures themselves are composed entirely of work similar to what is called, in America, crib-work, and the timbers composing it are cut out of material measuring 1 foot 6 inches square; to strengthen the merlons there is an outside casing, which joins the interior angles of the cheeks of the embrasures, and between the outside and inside casings there is a thickness of 6 feet of sand: the whole of each merlon is also covered by a parapet of sand of immense thickness, and it was evident that all the slopes were to have been revetted with sod-work of great thickness, but the Russians had not sufficient time to complete it.

The wood of which it is composed is pine, and the magazine which is in the epaulment, at the end of the casemated battery, is of similar construction and material, and is rendered quite bomb-proof by an enormous mound of sand which has been heaped over it.

There were 19 embrasures in this battery, but only 9 guns had been mounted in it.

The work nearest to the fort was of the same oblong form, but of much simpler construction, the guns being mounted on a raised terreplein, and firing through very wide embrasures, the interior slope being indented. In this, as in the other, the great preponderance of fire was directed towards the channel before mentioned, indeed their deficiency of flank defence or ditch renders it evident that they were merely intended for the purpose of defending it; and here it may be remarked that as their fire cut neither yard nor spar of any of those vessels which forced the passage, and did not in any way impede them, they completely failed n fulfilling the purpose for which they were constructed.

This fort, or rather battery, (for they should neither of them be called by the former name) had its magazine in a similar position to that of the latter, and the entrance to it was protected by a bomb-proof block-house constructed on the same principles as the casemates of the outer battery, and evidently intended to serve the purpose of a barrack as well as for defence.

The two small batteries were connected by a zigzag running along the spit, which had two high banks on either side to protect the people passing along it from cannon shot or musketry, and was directed so that no portion of it could be enfiladed by either battery.

LOTHIAN NICHOLSON,

Captain Royal Engineers.

October 22nd, 1855.

APPENDIX.

(Extract from Lord Lyons's Despatch, dated October 18th, 1855, describing the capture of Kinburn.)

"I have the honor to state that we arrived at a rendezvous off Odessa on the 8th inst., but, owing to strong south-west winds, which would have prevented the troops from landing, it was not until the morning of the 14th inst. that the expedition was enabled to reach the anchorage off Kinburn.

"During the night the English steam gun-vessels Fancy, Boxer, Cracker and Clinker and four French gun-vessels forced the entrance into Dnieper Bay, under a heavy but ineffectual fire from the Spit Fort, and on the following morning the British troops, under the orders of Brigadier-General the Hon. A. A. Spencer, together with the French troops, under the command of General Bazaine, were landed about 3 miles to the southward of the principal fort, and thus, by these nearly simultaneous operations, the retreat of the garrison and the arrival of reinforcements were effectually cut off.

"In the evening, the English and French mortar-vessels tried their ranges against the main fort with excellent effect.

"The wind having again veered round to the southward, with a great deal of swell, nothing could be done on the 16th, but on the forenoon of the 17th a fine northerly breeze, with smooth water, enabled the French floating-batteries, mortar-vessels, and gun-boats, with the Odin and the mortar-vessels and gun-boats named in the margin to take up positions off Fort Kinburn; and their fire was so effective that before noon the buildings in the interior of the fort were in flames, and the eastern face had suffered very considerably.

"At noon, the Royal Albert, the Algiers, the Agamemnon, and the Princess Royal, accompanied by Admiral Bruat's four ships of the line, approached Fort Kinburn in a line abreast, which the shape of the coast rendered necessary, and the precision with which they took up their positions in the closest order with jib-booms run in, and only 2 feet of water under the keels, was really admirable. At the same moment the squadron under the orders of Rear-Admirals Sir Houston Stewart and Pellion pushed through the passage between Oczakoff and the spit of Kinburn, and took the forts in reverse, while the St. Jean d'Acre, the Curaçao, the Tribune and the Sphinx undertook the centre battery, and the Hannibal, Dauntless and Terrible that on the point of the spit.

"The enemy soon ceased to reply to our overwhelming fire, and, though he made no sign of surrender, Admiral Bruat and I felt that a garrison which had bravely defended itself against so superior a force deserved every consideration, and we therefore made the signal to cease firing, hoisted a flag of truce, and sent on shore a summons, which was accepted by the Governor, Major-General Kokonowitch; and the garrison, consisting of 1,400 men, marched out with the honours of war, and laid down their arms on the glacis, and, having surrendered themselvesas prisoners of war, they will be embarked in Her Majesty's ship Vulcan to-morrow.

"The casualties in the Allied fleets are very few, amounting in Her Majesty's ships to only 2 wounded. The loss of the enemy in killed and wounded is, I fear, very severe.

"In the three forts, which have suffered considerably by our fire, we found 81 guns and mortars mounted, and an ample supply of ammunition.

"This morning the enemy has blown up the forts on Oczakoff Point, which mounted 22 guns, and we learned from a Polish deserter, who escaped in a boat from them during the night, that the Commandant apprehended an attack from our mortar-vessels, which would not only have destroyed the forts but also the neighbouring dwellings."

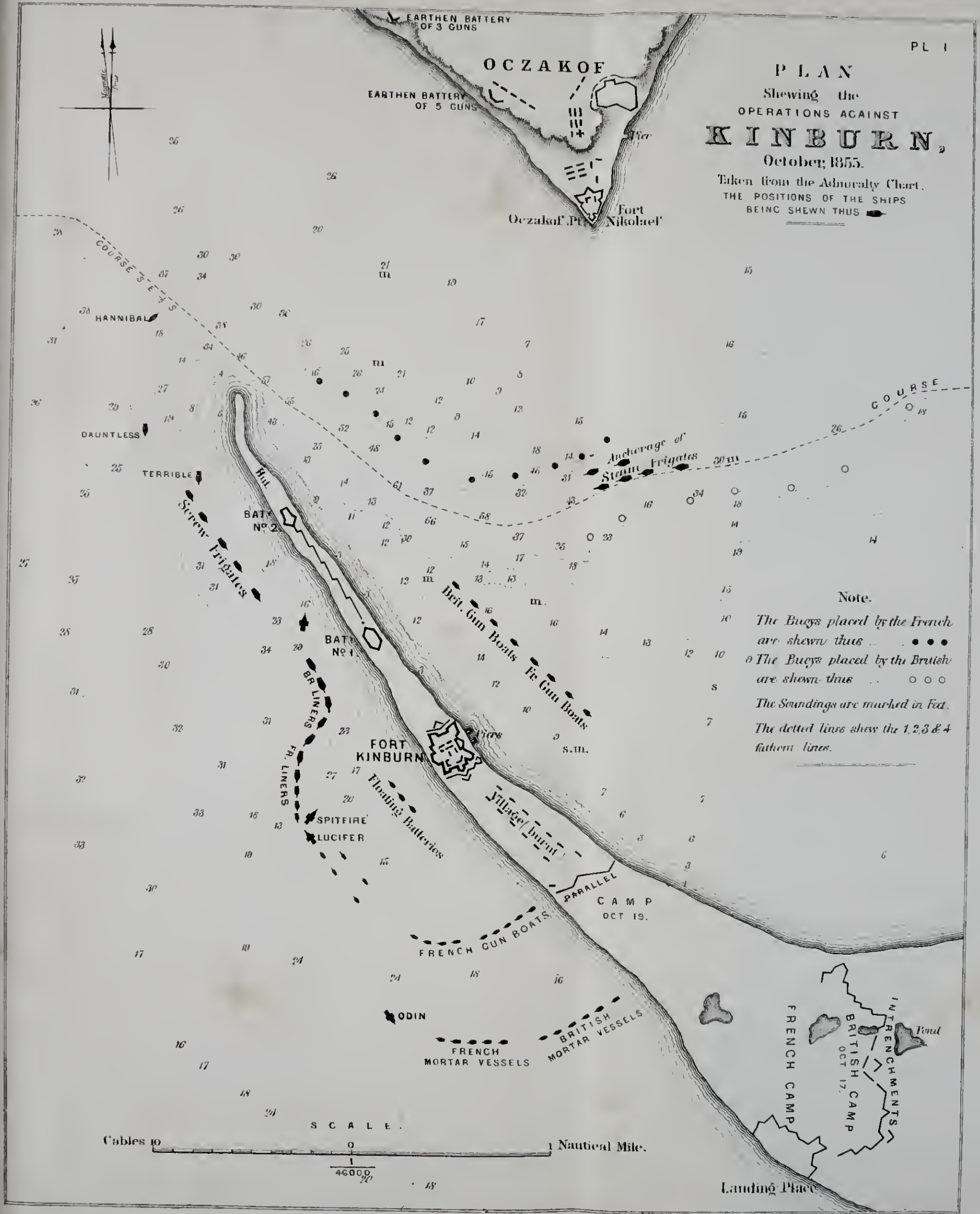
(Extract from Brigadier-General Spencer's Despatch describing the Operations at Kinburn.)

Her Majesty's Ship Royal Albert,
off Sebastopol, November 4, 1855.

"Sir,—In reporting the return of the Expeditionary Land Force under my command from Kinburn, I am now enabled to make, for the information of the Commander-in-Chief, a more ample report of their proceedings than in my previously hurried despatch I was able to do.

"The landing of the troops three miles from Kinburn Fort was effected without opposition on the 15th October. Owing to a heavy surf, there was considerable

PL. I



PLAN
Shewing the
OPERATIONS AGAINST
KINBURN,
October, 1855.
Taken from the Admiralty Chart,
THE POSITIONS OF THE SHIPS
BEING SHEWN THUS

Note.
The Buoys placed by the French are shewn thus ● ● ●
The Buoys placed by the British are shewn thus ○ ○ ○
The Soundings are marked in Feet.
The dotted lines shew the 1, 2, 3 & 4 fathom lines.

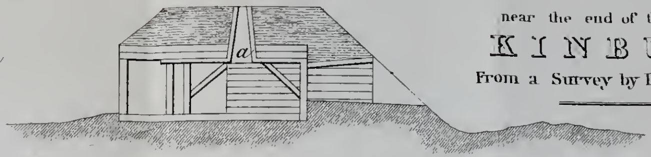
C. Moody, Lith. 257, Holborn, London

PL. 2

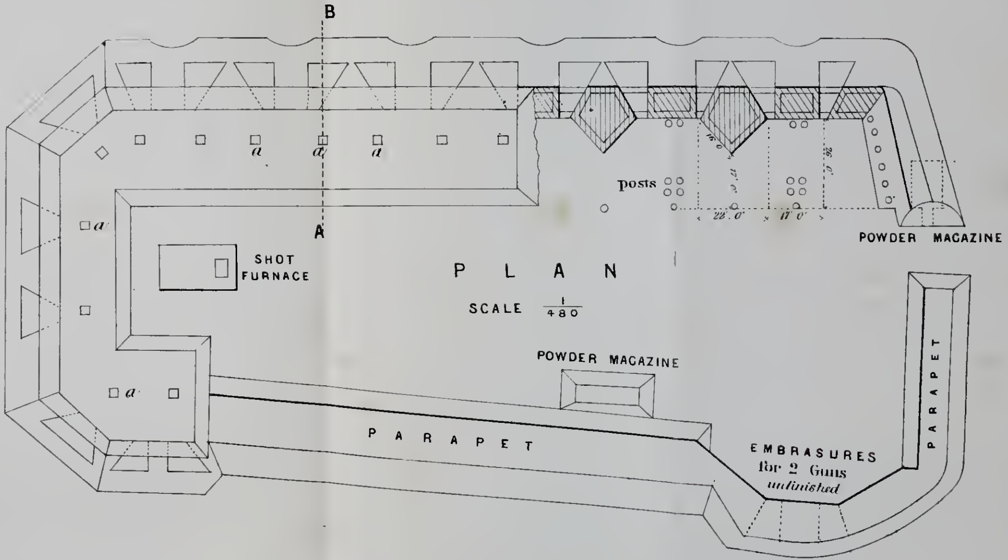
PLAN
OF THE
SAND BATTERY,
near the end of the Spit at
KINBURN,
From a Survey by Lt. C. Gordon, R.E.

Note.
This Battery was unfinished when attacked on the 17th October, 1855.

SECTION ON A. B.
SCALE $\frac{1}{240}$

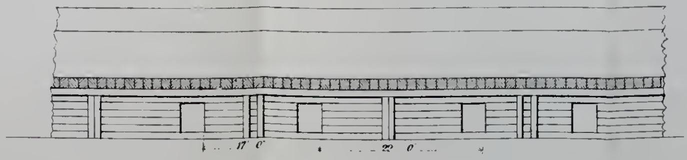


The timbers for the upright posts are 1'. 6" to 1'. 9" in diameter; and those for other parts are 9" × 8". a. a. are ventilators.

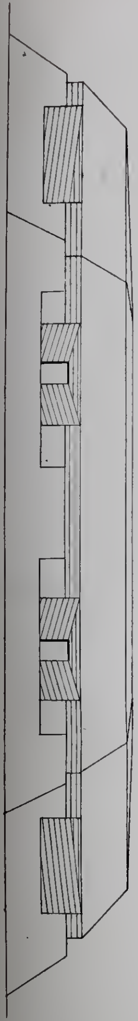


PLAN
SCALE $\frac{1}{480}$

ELEVATION OF THE INTERIOR



SCALE $\frac{1}{240}$



ELEVATION OF THE EXTERIOR.
SCALE $\frac{1}{240}$

C Moody Lith. 257, Holborn, London.

difficulty in it, but the infantry were all on shore by 11 o'clock (it commenced at 8 A.M.); and from the activity of the Royal Navy employed, the Cavalry and most of the Artillery were landed in the course of the day, though the first portion of the Commissariat was only landed, and with great difficulty, on the evening of the second day.

"The whole force was very shortly in position. The orders I had received from the French General Bazaine were to protect with the English troops the right flank from any attack the enemy might make for the relief of the garrison from Nicolaieff or Kherson, whilst the French line was to be in our rear, but facing the fort.

"The ground I occupied was about a mile in extent; the regiments were deployed into line, every advantage being taken of the nature of the ground, which was undulating.

"The tents were pitched in rear of the battalions as they arrived from the landing-place. The regiments were employed immediately after landing in intrenching their own front, thus making our general line of field works from the sea on either side. A work was also thrown up in the course of the following day, on the left flank of the line, to be occupied by field-pieces or by ship guns, should the fort not fall immediately. The nature of the ground rendered any assistance from the allied gun-boats impossible.

"The French had hastily thrown up a place d'armes in rear of our right, from which a re-embarkation, if necessary, might have been satisfactorily accomplished.

"The bombardment from the ships commenced on the afternoon of the 15th, but from the state of the weather it was discontinued; and on the 16th they were unable to resume it from the same cause.

"By the morning of the 17th, the field works thrown up by the troops were, as far as circumstances would admit of, very defensible, although too extensive. The outlying pickets had also thrown up small entrenchments at their respective posts. That morning at day-break I made a reconnaissance with the detachments of French and English cavalry and the 57th Regiment. The weather becoming thick, the infantry returned after a march of four miles out. The cavalry proceeded to the village of Paksoffka, a few miles further, which they found deserted. At 10 A.M. the ships opened fire, and at three o'clock the forts surrendered, with about 1,400 prisoners. 17 officers and 739 men were given over to me by General Bazaine, and were subsequently sent on board Her Majesty's ship Vulcan, to proceed to Constantinople. On the following morning the forts at Otchakoff were blown up by the enemy. French and English commissioners were appointed for the taking over of the material found in the forts of Kinburn, and for the temporary division of the place".

PAPER XII.

ACCOUNT OF THE OPERATION OF BLASTING THE ROCK AT THE HOLYHEAD QUARRIES ON THE 16th JANUARY, 1857, FOR THE SUPPLY OF STONE FOR THE NEW HARBOUR WORKS IN PROGRESS AT THAT STATION.

BY COLONEL SERVANTE, ROYAL ENGINEERS.

The system of quarrying stone, by the old process of boring, and blasting with small charges, for the construction of the pier or breakwater at the new harbour at Holyhead, which obtained at the quarries there prior to the year 1850, having been found inadequate to meet the periodical supply which was demanded by the terms of the contract, the contractors (Messrs. Rigby) had recourse to the more eligible processes of *mining*, and employing greatly increased charges of powder, whereby they have since been enabled to fulfil the conditions of their contract, dislodging from the rock large masses of stone by a single explosion.

Some account of the mining operations at the Holyhead quarries subsequently to the period above stated, by Captain C. S. Hutchinson, R.E., have already appeared in the 2nd Vol. of the " New Series of the Professional Papers," and the operation of the 16th January, 1857, was a continuation of the system therein adverted to, which has been carried on with so much success by the judgment and spirited exertions of Mr. C. Rigby, aided by Mr. Reitheimer, the Engineer attached to the Firm.

By the directions of the Inspector-General of Fortifications I proceeded to Holyhead to witness the explosion of 16,000 lbs. of powder on the day adverted to, and to report the result.

The quarries opened and worked by Messrs. Rigby are situated on the declivity of the Holyhead mountain, and a portion of rock facing the north was that intended to be dislodged on that occasion. The rock is of schistous quartz, intersected with veins of crystalline quartz, from 1 to 20 inches in thickness. The stratification of the rock in these quarries appears to be generally horizontal at the lower level, whilst that of the higher level is vertical; the portion which was brought down on the occasion referred to formed nearly horizontal strata, inclining from west to east, its average height being 115 feet and length 210 feet.

An entrance gallery 23 feet long, and 5′ 6″ + 3′ 6″ (see Plate), was driven from the face of the rock, at the extremity of which a shaft 6′ + 5′ was sunk to the depth of 23 feet, and from that level galleries were driven to the right and left, 85 feet and 78 feet long respectively, with two returns in each, as shown in the Plan. All the chambers (which were 6 ft. × 4 ft.), were three feet below the level of the ground-line of the quarry, as it had been found by experience that when formed above that level a wall of rock had been left standing after an explosion, which entailed great additional after-labour and expense to remove it.

The powder for loading the chambers was contained in canvass bags, well coated with Stockholm tar, and the chambers were closed by dry walls of stone 3′ 6″ in thickness.

The galleries and shaft were tamped with stiff red clay, obtained from strata found in the quarries (which is found to answer admirably) and the tamping was carried through the entrance gallery to the face of the rock.

The method employed in estimating the total quantity of powder for loading the 4 chambers was as follows, viz.:—the cubical content of the mass to be dislodged was divided by 12, the minimum number of cubic feet per ton (the rock varying from 12 to 14 feet per ton), and the result divided by 5, the assumed datum being that 1 lb. of powder was sufficient to dislodge 5 tons of stone—the formula adopted therefore in the present instance was $\frac{210 \times 115 \times 40}{12} \div 5$.

The quantities apportioned to Nos. 1, 2, 3 and 4 chambers (the lines of least resistance being respectively 26 ft., 25 ft., 20 ft. and 27 ft.), were 4,200 lbs., 4,500 lbs., 2,300 lbs , 5,000 lbs.; these charges were not calculated by any specific formula, founded on the lengths of lines of least resistance cubed, but by the relative lengths of these lines, the degree of tenacity of the rock which each would more immediately act on, and the presence of joints which would tend to disunite the mass from the main rock.

At a given signal the mines were fired by the Voltaic battery (46 cells) and with very successful results.

The mass was quietly overthrown, down to the level of the quarry ground-line, with very little noise; and scarcely a stone was thrown into the air. The quantity was found by measurement to be about 120,000 tons, in blocks of from 3 to 40 tons, thus averaging 7½ tons of stone per pound of powder; but probably it will be found to be more by actual weight, as I understand from Mr. Rigby that the quantities are generally found to be greater when weighed (which they always are when in transit to the breakwater), than they were assumed to be by measurement in the first instance.

The extreme length of range to which any blocks of stone were propelled was 430 feet from the face of the rock. The rails laid down in the quarries for the transit of stone were removed, previously to the explosion, as far only as it was presumed would be the limit of its sphere of action.

A well protected shed was erected for the accommodation of visitors, facing the rock to be exploded, and about 600 yards from its base, where the operation was witnessed in perfect security; the weather was fine and clear, with a moderate breeze from the north-west.

A singular incident took place at the moment of explosion: a goat, which was browsing on the top of the rock, was propelled on a block of stone upwards of 400 ft., and jumping from it just before it came in contact with the ground, alighted on its legs unhurt, saving a trifling cut on one leg.

The subjoined detail of preliminary operations may probably be interesting—

8 miners were employed working in two reliefs (during the 24 hours) for 8 months, whose wages averaged from 18s. to 22s. per week, according to the quantity of work executed.

1 smith and 1 striker employed sharpening tools 75 days each.

	cwt.	qrs.	lbs.
Iron used.	14	2	2
Steel do.	1	2	8
Coals do.	16	0	0

Powder used in driving galleries, &c., 727 lbs.

Biekford's fuze, 1600 yards.

Oil for lighting, 14¾ gallons, which, having been used in well constructed lamps with small wicks, is stated to have preserved the air purer than when candles were used, and to have effected a saving of 20 per cent by its adoption.

The powder used was procured from Messrs. Curtis and Harvey, and was manufactured for Messrs. Rigby; its strength is tested by an 8-inch mortar charged with 1½ oz. of powder, which gives a range of from 300 to 330 feet, at 45°, to a 68-lb. polished shot.

The chambers were not lined, but 1-inch flooring planks were laid 3 inches above the level of the chamber floor.

Each barrel of powder was opened with a wooden mallet, the contents were emptied into small canvass bags, which were handed through the galleries by 40 to 50 miners, and then emptied into one large bag (intended to contain the entire charge for the chamber), by a person appointed to perform that duty: a charge of from 4,000 to 5,000 lbs. was in this manner securely lodged in about 30 minutes. To prevent accident, the whole of the floors were covered with a layer of clay 1 inch thick, as it is stated that the miners employed in this and similar operations wear boots with iron nails. It is also the duty of the foreman of a section to inspect each man's pockets, as they are in the habit of carrying matches on their persons. The bursting charge was inserted into the bag, and well secured to prevent its being disturbed by the tamping, the wires were conducted along the head of each chamber and gallery to the face of the rock, and were frequently tested during the progress of tamping by the "indicator" to ascertain that the electric current was perfect, after which the entrances of the chambers were closed by a dry wall of stone 3 ft. 6 in. thick, and the whole of the galleries and shafts were then tamped with clay by means of a wooden rammer.

Upwards of 800 tons of powder have by this process been safely lodged during the mining operations carried on at the Holyhead quarries without a single accident on record. Bags for containing the charges are prepared at the establishment for from 500 to 5,000 lbs. of powder each.

The Voltaic battery used was constructed at Messrs. Rigby's establishment on the spot, and was on "Groves" principle; the copper wire was spun with calico on a drum.

It will be seen by the plan that the line of explosion was restricted by a high rock on either side, opposing a lateral resistance, and thus lessening the effect which would have been otherwise produced, and which would probably have given a result of 20 additional tons of stone.

It appears doubtful whether a saving might not have been effected in the extent of the galleries and shaft leading to the chambers, without lessening the results.

The time occupied in the preliminary operations appears to be great, but I understand that it does not exceed the average of similar operations at these quarries.

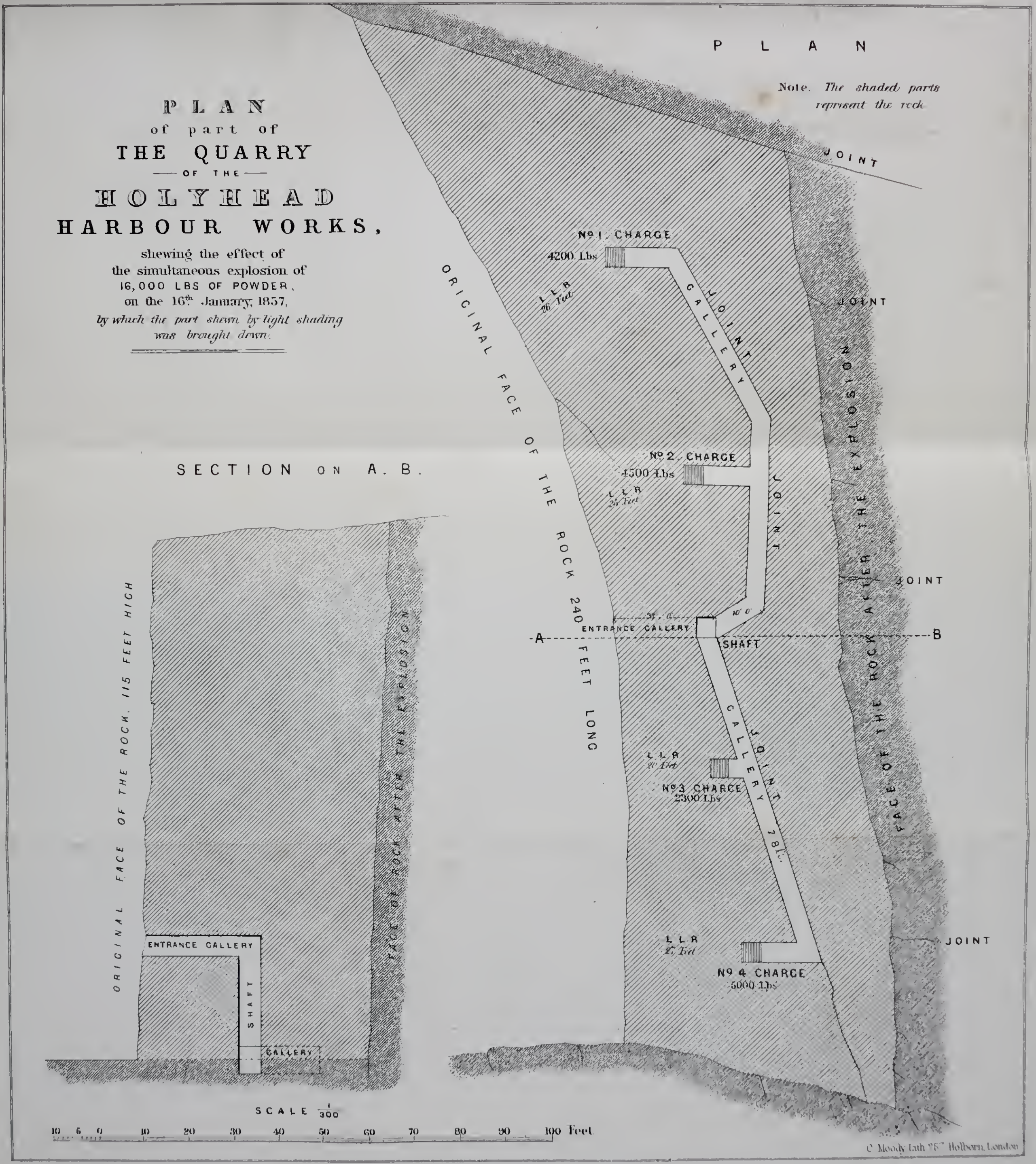
The miners employed at the quarries are paid by the lineal foot and not by the cubic foot of gallery driven, and they invariably prefer making these galleries of great area, the convenience of which they consider more than compensates for the lesser amount of excavation in smaller galleries.

W. SERVANTE,

5th February, 1857. Lieut.-Col. Royal Engineers.

PLAN
of part of
THE QUARRY
— OF THE —
HOLYHEAD HARBOUR WORKS,

shewing the effect of
the simultaneous explosion of
16,000 LBS OF POWDER,
on the 16th January, 1857,
by which the part shewn by light shading
was brought down.



C. Moody Lith. 257 Holborn London

PAPER XIII.

ACCOUNT OF A NEW CEMENT, AND OF THE EXPERIMENTS WHICH LED TO ITS DISCOVERY.

By CAPTAIN H. SCOTT, ROYAL ENGINEERS.

I have been assured by several of my brother officers that others as well as themselves would feel an interest in my experiments on limes and cements, and I am therefore induced to offer, for insertion in the Professional Papers, the following brief account of them.

During the progress of the new works at Gibraltar, much difficulty was experienced in putting in the foundations of the escarp wall of Jumper's Battery from the quick decomposition of the shale, which had to be excavated to a depth of 8 feet to receive them. On more than one occasion this decomposition proceeded so rapidly as to have endangered the lives of the men who were at work on them, and some interest was excited concerning the cause of the rapid change from a hard rock to semi-fluid mud.

After my return to England, having acquired a slight knowledge of chemical analysis, I begged General Harding, then Commanding Royal Engineer at Gibraltar, to send me specimens from different parts of the rock, and especially of this shale.

The shale contained—

	No. 1.	
Lime.	29·55	
Magnesia.	·92	
Alumina.	1·59	
Iron oxyde.	4·68 *	
Carbonic acid.	22·84	
Sulphuric acid.	·07	
Sulphur.	traces	
Soluble in hydrochloric acid.		59·65
Silica.	30·15	
Alumina.	2·78	
Iron oxyde.	1·53	
Potash.	·07	
Soda.	·39	
Loss.	·45	
Insoluble in hydrochloric acid.		35·37
Bituminous matter.		1·50
Hygroscopic moisture.		1·64
Loss.		1·84
		100·00

* Traces in the state of sulphuret, to which apparently the decomposition of the rock was chiefly due, the sulphuret having changed into the soluble sulphate of iron under the action of the atmosphere.

And having learned from the works of Smeaton, Sir Charles Pasley and others, that hydraulic limes and cements contained a proportion of clay, I was naturally led to suspect that a limestone of the above composition might yield a cement; and, in fact, on trial, this specimen after calcination sets in 7 or 8 minutes.

Another specimen, taken from the shore of the town-front, consisted of—

	No. 2.	
Lime.	19·76	
Magnesia.	·99	
Alumina.	4·46	
Iron oxyde.	7·96	
Carbonic acid.	15·56	
Sulphuric acid.	traces	
Sulphur.	traces	
Soluble in hydrochloric acid.		48·73
Silica.	43·72	
Alumina.	1·59	
Iron oxyde.	1·68	
Potassa.	·12	
Soda.	·27	
Insoluble in hydrochloric acid.		47·38
Bituminous matter		1·90
Hygroscopic moisture.		1·40
Loss.		·59
		100·00

This also yielded a cement, but inferior to the first. Here the quantity of clay was in excess, and the cement worked very short.

The next specimens examined were taken, I believe, from what is termed the "black rock" on the north front, and contained—

	No. 3.		No. 4.	
Lime.	50·35		36·79	
Magnesia.	traces		1·10	
Alumina.	—		·15	
Iron oxyde.	traces		1·62	
Carbonic acid.	40·72		29·52	
Sulphuric acid.	—		·06	
Sulphur.	traces		traces	
Soluble in hydrochloric acid.		91·07		69·24
Silica.	8.40		19·47	
Alumina.			·15	
Iron oxyde.			4·74	
Potassa.			1·62	
Soda.				
Loss.				
Insoluble in hydrochloric acid.		8·40		25·98
Bituminous matter.		·66		2·24
Hygroscopic mixture.		·14		·80
Gain or loss.		— ·27		+ 1·74
		100·00		100·00

No. 3 yielded a moderately hydraulic lime, and No. 4 what might be termed a cement, and which, when allowed to set before immersion, soon surpassed in hardness No. 1.

The beds, however, from which these stones were taken were never used for lime, because, as I have understood, they afforded a substance which, after calcination, slaked imperfectly, or not at all; and yet, if treated properly, they would have made mortar far superior to that produced from the pure and white limestones made use of for this purpose. The following are analyses of specimens taken from the white beds alluded to, which were also worked for ashlar and backing.

	No. 5.	No. 6.
Lime.	55·53	55·23
Magnesia.	·20	·64
Alumina.	——	a trace
Iron oxyde.	a trace	——
Carbonic acid.	43·76	43·30
Silica.	——	·20
Bituminous matter.	·30	·30
Hygroscopic moisture.	·14	·18
Loss.	·07	·15
	100·00	100·00

Whilst these experiments were in progress, I had the good fortune to be visited by Sir William Reid (then Commanding Royal Engineer at Woolwich), who took so much interest in what I was about, that he procured the sanction of the Inspector-General of Fortifications to my giving some instruction to the officers and non-commissioned officers in the mode of testing calcareous limes and cements; and to enable me to carry this out, and to prosecute my own experiments more conveniently, he obtained the use of an unoccupied building at the bottom of the Sappers' drill ground.

Shortly afterwards I made an examination of some specimens of limestone from Plymouth, and, amongst others, of one from a slaty bed which very much interfered with the working of the quarry in which it occurred. It varied from 12 to 14 feet in thickness, and being unfitted for building purposes, or, if burned to lime, slaking imperfectly, was carted to waste at a heavy expense.

I cannot now find my own analysis of this stone, but it appears, from an examination recently made of it, after calcination, by Ensigns Meade and Birney of the Hon. East India Company's Engineers, that it contains, approximately, of

Lime.	62
Magnesia.	3
Iron and alumina.	7·5
Silica.	22·5
Sulphuric acid, chorine, potash, soda, and loss.	5
	100·0

and in common with other beds of similar composition in its immediate neighbourhood, it has since been proved by experiments, carried on in the Royal Engineer yard at Devonport, to yield a lime that, in dry situations, (in which alone the comparison was made) can compete in strength with the Lias, whilst it can be supplied in Plymouth and the neighbourhood at less than two-thirds of the cost of that material. It is now being used in a portion of the government works instead of the Lias.

Whilst experimenting on this bed, it so happened that a piece which had been placed in a dining room fire for calcination, was allowed to remain there for some time after the fire had burned dull, cinders and ashes having been thrown upon it. On taking it out, and trying, by the application of some acid, whether it was properly burned, it effervesced with violence, and was therefore again returned to the fire. This however was so choked that it would not burn with sufficient brightness to expel the carbonic acid from the stone, and on a second trial it effervesced as much as before. Somewhat impatiently, I rubbed it into a powder, mixed the powder with water, and waited in expectation of seeing it slake; but instead of this, much to my surprise, it gradually hardened into a solid mass. A repetition of the experiment produced the same result, and it succeeded equally well with pure lime. Contrary to my first expectations, however, I found it necessary to burn the stone or chalk to lime before placing it between the feebly glowing cinders, as their temperature was not sufficient to expel any appreciable amount of carbonic acid from the particles below the surface. The carbonic acid found to be present in my first experiment had probably been all re-absorbed, as there was no visible core, and at a low red heat this gas is readily taken up again. Some specimens of it were then shewn to Dr. Faraday, Dr. Wm. Allan Miller, and Mr. Abel, now Chemist to the War Department, and finding that the phenomenon was new to them, and I was aware that it was so to lime burners, I was induced to take out a patent for the discovery. I then conceived that the effect was due to the conversion of the lime into a sub-carbonate, but subsequent experiments and analysis having convinced me that the substance produced would set equally well though no carbonic acid were combined with it, I procured a second patent "for subjecting quick lime in a heated state to an atmosphere arising from the combustion of coke, coal, and substances of a like nature." The lime was to be supported on iron bars, or on a perforated floor, and kept for about 24 hours at a dull glow by coke burning, or as I may term it, smouldering, on the fire-bars beneath.

This process answered perfectly so long as I confined myself to operating on quantities of 4 or 5 bushels, and I imagined that with an increase of scale a great saving of fuel would be effected, but when Messrs Lee and Co., who proposed working the patent, attempted to carry on the process on a manufacturing scale, they found the results so variable, and the consumption of coke so large, as to render the mercantile success of the plan very doubtful.

I was compelled therefore to return to my experiments on a small scale, and, assisted and encouraged by Colonel Sandham, the Director of the Royal Engineer Establishment, I not only tried every form of kiln which I thought might render the process surer in its results and more economical, but commenced a fresh series of laboratory experiments with the different products arising from the combustion of coke and coal. I omitted, however, to try the effect of sulphurous acid, both now and on former occasions, because, as I believed, the required effect had been produced with charcoal which could not have generated it. Unfortunately, the experiment on which this belief was founded was tried by another person. My substitute found his charcoal running short, and made it out with a little coke;—so little, however, he assured me, that it could not influence the result. The result was successful, and whenever afterwards the idea of trying any of the compounds of sulphur and oxygen suggested itself, I dismissed it on the strength of this experiment.

One night, however, I happened to charge my furnace with fresh fuel in the dark, and my attention was attracted by the ignition of some particles of sulphuret of iron rubbed from the coke as it was thrown in. The possibility of my having been deceived as to the quantity of coke used in the experiment above alluded to, arose in my mind, and I determined at all events to try the effect of sulphurous acid, for all the other products of the combustion of coke, whether tried singly or combined, had failed to produce the desired effect when generated in any other way. The following morning, then, a few pounds of sulphur were thrown in with the coke during the usual kiln process, and, at the end of a much shorter time than I commonly allowed, the contents of the kiln were examined, and found to be in the state desired. At the same time to ascertain whether sulphurous acid, produced in any other manner, and without an admixture of other gases, would yield similar results, an iron pipe containing a few pieces of quick lime was passed through the kiln, so that they might be kept at the correct temperature, and a current of sulphurous acid evolved by acting on sulphuric acid with copper, was passed over them, and this also proved successful.

In the next experiment the lime in the kiln was first raised to the required temperature, and then the firing having been raked out, a pot of ignited sulphur was introduced, and the ash-pit and fire-door closed, so as to admit only sufficient air to continue its combustion. Here again the results were satisfactory, and a third patent was immediately secured "for subjecting lime in a heated state to the action of sulphurous acid.''

In carrying out this process, the following method is at present practised :—

Quick lime, prepared by any of the ordinary methods, is placed on a perforated arched floor in a layer 3 feet deep, having beneath it a fire-place 1 foot broad, with cheeks sloping outwards to the full width of the kiln, and extending throughout its whole length. The fire-bars are 1′ 3″ from the ground, and the perforated fire-brick arch consists of two 4½ inch rings, 3′ 6″ above them. The whole is covered in with a 9-inch semicircular arch, springing 2′ 6″ above the perforated floor.

At the end of the kiln furthest from the fire-door, is a hatch or opening 2′ 6″ wide and 4′ high, for charging and drawing. This is closed during the process with a double wall of bricks, having an intermediate space of a few inches filled with lime dust. The chimney is over the hatch, and is raised about 1 foot above the outer ring of the semicircular arch which forms the roof.

The kiln is 6 feet long and 2′ 6″ broad, and therefore in a depth of 3 feet contains 3 cubic yards of lime.

The kilns which the manufacturers propose to erect (that above described being intended for experimental purposes only) will be about 23 feet long and 10 feet wide, with 4 fire-places, two at either end, separated by a wall of brick extending to the height of the perforated floor. In other respects they will differ little from the small kiln here described.

When the charge of lime has been raised to a dull glow, the firing is raked out, and 30lbs. of sulphur are introduced into the ash-pit in iron pots. As soon as this sulphur is fully ignited, the chimney is shut up, and the ash-pit and fire-door closed, some little air still finding its way in and continuing its combustion. At the end of 7 or 8 hours, (in my three bushel kiln I found 2 hours sufficient) the charge is raked out, ground to powder, and packed in casks for use.

The nature of the lime, as respects its mode of combining with water, is now strangely altered ; for, instead of slaking, it will, when mixed up with it, gradually harden into a stone-like substance.

The process is applicable to any lime, but that which will be used principally in London and the neighbourhood is the well known Halling lime, prepared from the lower chalk, and possessing feeble hydraulic properties.

The following circular from the manufacturers, Messrs. Lee, Son and Smith, of the Halling Lime Works, near Rochester, will explain its application and the mode of treating it.

" This Cement possesses, for internal purposes, where an imitation of white marble is not intended, all the valuable properties which have brought the expensive Parian and Keene's Cements into use, and *it can be employed more cheaply than ordinary lime and hair plaster.*

"It is also admirably adapted for external coatings; for when exposed to the atmosphere, it enjoys the conditions most favourable to its strength, and it dries to that pleasing light buff, which is termed stone colour, and of which we have an example in the Magnesian Limestone selected for the construction of the Houses of Parliament.

"It does not, like the Roman Cement, require great skill in its application, the time in which it sets being just that which a plasterer requires.

"As a mortar, or for concrete, it possesses remarkable cementitious properties, and for Hydraulic purposes is superior to the much-esteemed Lias Lime."

Instructions for Use.

"The cement must be kept dry and protected from the air.

"Use 3, 4, or 5 parts of sand to 1 of cement, for a rendering coat; and 3 of sand, or less, to 1 of cement, for finishing, according to the work required. The sand to be clean and sharp, and for the rendering coat *coarse.*

"The surface to which it is to be applied, particularly if the brickwork be old, must be well wetted. If this precaution be not attended to, the cement is robbed of the water which is necessary to its becoming a solid mass, and crumbles from the wall. The effect will occur within one or two days of its being put up.

"In summer time, if exposed to the sun, the cement should be occasionally wetted for a day or two, to prevent a too rapid desiccation, which detracts from the hardness it is otherwise capable of assuming.

"If used for moulding purposes (when 1 or 2 parts of sand to 1 of cement may be employed) the cast must be well wetted, or, still better, immersed in water for an hour or two, before it has become thoroughly dry.

"For mortar, use 3 or 4 parts of sand to 1 of cement.

"For concrete, treat it like ground Lias Lime."

HENRY SCOTT, Captain, R.E.

PAPER XIV.

ON THE DEFLECTION OF THE PLUMB-LINE AT ARTHUR'S SEAT, AND THE MEAN SPECIFIC GRAVITY OF THE EARTH. COMMUNICATED TO THE ROYAL SOCIETY BY LIEUTENANT-COLONEL JAMES, R.E.,F.R.S.,M.R.I.A., &C., SUPERINTENDENT OF THE ORDNANCE SURVEY.

The Royal Society has, from the very commencement of the Ordnance Survey of the United Kingdom, taken a deep interest in its progress. I have therefore great pleasure in announcing to the Society the completion of all the computations connected with the Primary Triangulation, the measurement of the Arcs of Meridians, and the figure and dimensions of the Earth.

The account of all the operations and calculations which have been undertaken and executed is now in the press, and will shortly be in the hands of the public.

After determining the most probable spheroid from all the astronomical and geodetic amplitudes in Great Britain, we find that the plumb-line is considerably deflected at several of our principal Trigonometrical Stations, and at almost every station the cause of the deflection is apparent in the configuration of the surrounding country.

The deflection of the plumb-line at Arthur's Seat is $5''\cdot25$, and at the Royal Observatory at Edinburgh it amounts to $5''\cdot63$ to the South. The unequal distribution of matter here, the great trough of the Firth of Forth being on the North, and the range of the Pentland on the South, presents a tangible cause for the deflection ; but as the contoured plans of the county of Edinburgh are published, and we have the most perfect data that it is possible to obtain for estimating the amount of local attraction at Arthur's Seat and the Calton Hill, and as it appeared to me that an investigation of this matter was not only necessary to confirm and establish the results arrived at from the previous investigation of all the observed latitudes, but would also prove highly interesting to science, I decided on having observations taken with Airy's Zenith Sector on the summit of Arthur's Seat, and at points near the meridian on the North and South of that mountain, at about one-third of its altitude above the surrounding country.

The observations were made by Sergeant-Major Steel of the Royal Sappers and Miners, during the months of September and October last ; 220 double observations of stars were taken at each Station, and the results have justified my confidence in him as an observer.

To Captain Clarke, R.E., I entrusted all the reductions and computations connected with these observations, as well as the computations of the local attraction at Calton Hill. The following communication has been drawn up by him, and I trust it will prove acceptable to the Royal Society, and do him credit as a mathematician.

I have myself examined the geological structure of Arthur's Seat and the whole of the county of Edinburgh, and have had the specific gravity of all the rocks ascertained, with the view of estimating the mean specific gravity of the whole mass; but although the geological structure of Arthur's Seat is well exposed, and we have deduced from its mean specific gravity (2·75) the mean specific gravity of the earth, viz., 5·316, it is not such a mountain as I should have selected for this special object.

Since these observations were made, on examining the correspondence connected with the Survey, with the view of drawing up an historical sketch of its progress for publication, I was agreeably surprised to find that the late Dr. Macculloch had been employed for six years, from 1814 to 1819, in examining the whole of Scotland for the purpose of selecting a mountain which, from its homogeneous structure, size, and form, would be best suited for observations for the purpose of determining the mean specific gravity of the earth, and that he considered the Stack Mountain in Sutherlandshire admirably suited for the purpose. The transfer of the whole force of the Survey from the North of England and Scotland to Ireland, prevented the late General Colby from undertaking this investigation; but as the Survey of Scotland is now in full progress, I purpose early in the spring to go down to the Stack Mountain, to have it and the surrounding country surveyed and contoured, and to have the observations taken for determining the attraction of its mass, and I trust at the close of the present year to lay the results before the Royal Society.

I forward herewith a model of Arthur's Seat, made from the contoured plan on the scale of 6 inches to a mile, and also an impression of the plan itself, with sections showing the geological structure of Arthur's Seat, and a table of the specific gravity of the rock of which it is composed.

HENRY JAMES,

February 7, 1856. Lieutenant-Colonel Royal Engineers.

In deducing from the observations made at the three stations on Arthur's Seat, with the zenith sector, the latitudes of those stations, if we assign to the resulting latitude given by any one star a weight equal to the number of observations of that star, the final latitudes of the three stations will stand thus:—

Stations,	Designated.	Latitude.	Number of Observations.
South Station.	S	55° 56′ 26″·69	427
Arthur's Seat (summit)[*] . .	A	55 56 43·95	425
North Station.	N	55 57 9·50	411

The latitudes thus obtained being affected by the errors of the assumed declinations of the stars, the amplitudes to be adopted as final are obtained in the following manner.

[*] The station on the summit of the hill was 14 feet from the Ordnance Trigonometrical Station, and bearing 18° North-west; the former is therefore 0″·13 North of the latter.

Let ϕ_1 ϕ_2 be the values of the amplitudes SA, AN to be determined, and let the stars observed at S and A only, give these values—

$$\phi_1=a,\quad \phi_1=a',\quad \phi_1=a''.\ .\ .\ .\ .$$

Let stars observed at A and N only, give the values—

$$\phi_2=b,\quad \phi_2=b',\quad \phi_2=b''.\ .\ .\ .\ .$$

Let stars observed at S and N only, give the values—

$$\phi_1+\phi_2=c,\quad \phi_1+\phi_2=c',\quad \phi_1+\phi_2=c''.\ .\ .\ .\ .$$

And let stars observed at S, A, and N give the values—

$$\phi_1=a_1,\quad \phi_1=a'_1,\quad \phi_1=a''_1\ .\ .\ .\ .$$

$$\phi_2=b_1,\quad \phi_2=b'_1,\quad \phi_2=b''_1\ .\ .\ .\ .$$

Let d, e, and the same letters accented, be taken to denote the number of times the stars of the first set are observed at S and A respectively. Let f, g and h, k represent the same quantities for the stars of the second and third set; and let n, p, q, and the same letters accented, be taken to denote the numbers of times the stars of the fourth and last set are observed at S, A, N respectively.

The values of ϕ_1 ϕ_2 adopted are those which render the quantity

$$\Sigma\left\{\frac{de}{d+e}(\phi_1-a)^2\right\}+\Sigma\left\{\frac{fg}{f+g}(\phi_2-b)^2\right\}+\Sigma\left\{\frac{hk}{h+k}(\phi_1+\phi_2-c)^2\right\}$$

$$+\Sigma\left\{\frac{np}{n+p}(\phi_1-a_1)^2\right\}+\Sigma\left\{\frac{pq}{p+q}(\phi_2-b_1)^2\right\}$$

a minimum. Making the differential coefficients of this quantity with respect to ϕ and ϕ_2 respectively $=0$, we obtain

$$H\phi_1+K\phi_2-L=0$$

$$K\phi_1+M\phi_2-N=0$$

in which equations

$$H=\Sigma\left(\frac{de}{d+e}\right)+\Sigma\left(\frac{hk}{h+k}\right)+\Sigma\left(\frac{np}{n+p}\right)$$

$$L=\Sigma\left(\frac{de}{d+e}.a\right)+\Sigma\left(\frac{hk}{h+k}.c\right)+\Sigma\left(\frac{np}{n+p}a_1\right)$$

$$M=\Sigma\left(\frac{fg}{f+g}\right)+\Sigma\left(\frac{hk}{h+k}\right)+\Sigma\left(\frac{pq}{p+q}\right)$$

$$N=\Sigma\left(\frac{fg}{f+g}b\right)+\Sigma\left(\frac{hk}{h+k}c\right)+\Sigma\left(\frac{pq}{p+q}b_1\right)$$

$$K=\Sigma\left(\frac{hk}{h+k}\right).$$

If μ be any number, the value of $\phi_1 + \mu\phi_2$ is

$$\phi_1 + \mu\phi_2 = \frac{(-\mu\mathrm{K} + \mathrm{M})\mathrm{L} + (-\mathrm{K} + \mu\mathrm{H})\mathrm{N}}{\mathrm{HM} - \mathrm{K}^2},$$

hence the error of $\phi_1 + \mu\phi_2$ depends upon the manner in which the errors of the quantities $aa_{,}\ldots b\,b_{,}\ldots c\ldots\ldots$ enter into this expression.

Let (γ_a) and (γ_b) be the sums of the errors of observation at S and A, of a star of the first set, the same quantities being accented for other stars. Let (a_b), (a_c) represent corresponding quantities for stars of the second set, (β_a), (β_c) and (ϵ_a), (ϵ_b), (ϵ_c) the same quantities for the third and fourth sets of stars.

Then L and N are affected with the errors

$$\mathrm{L} \quad \ldots \Sigma\frac{d(\gamma_b) - e(\gamma_a)}{d + e} + \Sigma\frac{k(\beta_c) - h(\beta_a)}{h + k} + \Sigma\frac{n(\epsilon_b) - p(\epsilon_a)}{n + p})$$

$$\mathrm{N} \quad \ldots \Sigma\frac{g(a_c) - f(a_b)}{f + g} + \Sigma\frac{k(\beta_c) - h(\beta_a)}{h + k} + \Sigma\frac{p(\epsilon_c) - q(\epsilon_b)}{p + q}.$$

From these expressions we may derive, finally, the following : if E be the probable error of an observation, the probable error of $\phi_1 + \mu\phi_2$ is

$$\frac{\mathrm{E}}{\mathrm{MH} - \mathrm{K}^2}\Big\{\mathrm{M}(\mathrm{MH} - \mathrm{K}^2) + 2\mathrm{PMK} - 2\mu\Big(\mathrm{K}(\mathrm{HM} - \mathrm{K}^2) + \mathrm{P}(\mathrm{HM} + \mathrm{K}^2)\Big) + \mu^2(\mathrm{H}\,(\mathrm{HM} - \mathrm{K}^2) + 2\mathrm{PKH})\Big\}^{\frac{1}{2}},$$

where

$$\mathrm{P} = \Sigma\frac{npq}{(n + p)(p + q)}.$$

The values of H, M, K, P, L and N are found to be

$$\mathrm{H} = 168{\cdot}93 \quad \mathrm{M} = 168{\cdot}52 \quad \mathrm{K} = 46{\cdot}06$$
$$\mathrm{L} = 362{\cdot}40 \quad \mathrm{N} = 182{\cdot}20 \quad \mathrm{P} = 49{\cdot}34$$

whence we obtain

$$\phi_1 = 17''{\cdot}00 \quad \phi_2 = 25''{\cdot}53 \quad \phi_1 + \phi_2 = 42''{\cdot}53.$$

Now the value of E is to be deduced from the differences between the individual and mean results given by the different stars. The sum of the squares of these errors is found from the whole of the observations to be 712·1, hence the mean square of an error of observation (1263 obs.) is 0·56, and the probable error of an observation consequently $= 0''{\cdot}50\,(= {\cdot}67\sqrt{0{\cdot}56})$.

We have therefore the probable error of $\phi_1 + \mu\phi_2$ equal to

$$\frac{0''{\cdot}50}{263{\cdot}4}\Big\{520{\cdot}48 - 544{\cdot}66\,\mu + 522{\cdot}04\,\mu^2\Big\}^{\frac{1}{2}} = 0''{\cdot}043\Big\{1 - 1{\cdot}046\mu + \mu^2\Big\}^{\frac{1}{2}},$$

so that the probable errors of ϕ_1 and ϕ_2 are each equal $0''{\cdot}043$.

As the differences of latitude are the quantities principally required, we may append these amplitudes to any one of the observed latitudes. Thus making use of the observed latitude of the South Station, namely 55° 56′ 26″·69, there will result by applying the above most probable amplitudes the following latitudes :—

Latitude of S = 55° 56′ 26″·69
" " A = 55° 56′ 43″·69
" " N = 55° 57′ 9″·22

The last two latitudes differ from those in the first table by about a quarter of a second each.

The amplitudes derived from the latitudes in the first table, when compared with those we have considered as most probable, show the following differences :—

A—S . . . . + 0″·26
N—S . . . . + 0″·02
N—S . . . . + 0″·28

Geodetical Amplitudes.

By means of a small network of triangulation connected with the secondary triangulation of the Ordnance Survey in the county of Edinburgh, the following results were obtained :—

From	To	Distance.	Bearing.
		ft.	° ′ ″
Arthur's Seat, Trigonometrical Station	S.	1426·7	179 42 7
	N.	2490·0	6 0 17

The bearings being reckoned from North round by East. The corresponding amplitudes are 14″·06 and 24″·40 : in order, however, to the comparison of these with the amplitudes before considered, the quantity 0″·13 must be added to the first of the geodetical amplitudes and deducted from the second for the difference of the two stations on the summit of the hill. The geodetical amplitudes are therefore

A — S = 14″·19
N — A = 24″·27
N — S = 38″·46.

By comparing these amplitudes with the actual astronomical amplitudes we find the following results :—

(1) Between the vertex of the hill and the South Station, the astronomical amplitude exceeds the geodetical by 2″·81.

(2) Between the vertex of the hill and the North Station, the astronomical amplitude exceeds the geodetical by 1″·26.

(3) Between the North Station and the South Station, the astronomical amplitude exceeds the geodetical by 4″·07.

Geodetical Latitudes.

The latitude of the Trigonometrical Station on the summit of Arthur's Seat is, when referred to, or projected on that spheroidal surface which best represents all the astronomically determined points in Great Britain,

55° 56′ 38″·31,

from which, by the application of the geodetical amplitudes, we obtain the latitudes of the other two points, shown in the following Table, in contrast with the observed latitudes :—

Station.	Astronomical Latitude.	Geodetical Latitude.	A—G.
	° ′ ″	° ′ ″	″
S	55 56 26·69	55 56 24·25	2·44
A	55 56 43·69	55 56 38·44	5·25
N	55 57 9·22	55 57 2·71	6·51

It might have been anticipated that, on account of the attraction of the hill at the South Station, the deflection of the plumb-line would have been to the north, which by throwing the zenith to the south would have caused the observed latitude to be less than its true value. The contrary, however, takes place, for the observed latitude is greater than the geodetical. On proceeding next to the second station, namely, that on the summit of the hill, a similar anomaly is observed ; there is an attraction or deflection to the south of more than five seconds, which can by no means be attributed to the hill, as its attraction upon any object at its vertex is very nearly equal north or south. A similar anomaly is visible at the North Station ; there is a deflection to the south of 6″·5, which is considerably more than that due to the mass of the hill, as will appear hereafter.

It is clear, therefore, that there is some *other* disturbing force acting at each of these stations besides the attraction of Arthur's Seat, and which appears to produce a *general deflection* to the south of about five seconds.

The comparison of the observed and calculated latitudes of the observatory on the Calton Hill serves to corroborate this fact. The latitude of this observatory, as determined by observation, is

55° 57′ 23″·20.

The latitude of the Trigonometrical Station on this hill, when referred to the same spheroidal surface we have before mentioned, namely, that agreeing most nearly with all the astronomically determined points in Great Britain, is 55° 57′ 17″·51 : the difference of latitude of these two points (taking the centre of the Altitude and Azimuth instrument of the observatory as the point whose latitude is above given) is 0″·06, so that the calculated latitude of the Calton Hill observatory is

55° 57′ 17″·57,

which is less than the astronomical by 5″·68 ; showing a deflection to the south of that amount in existence at the Calton Hill. Now the attraction of the mass of Arthur's Seat upon the Calton Hill is easily calculated to be between 0″·1 and 0″·2, consequently the deflection here visible is certainly not due to Arthur's Seat.

It seems therefore very probable that the general deflection of five seconds to the south, brought out at all these stations, is due to one and the same cause.

An explanation of this phenomenon immediately offers itself in the existence of the hollow of the Forth to the north, and the Pentland Hills and other high ground to the south, but whether these may be sufficient to produce the effect observed will be considered hereafter.

DEFLECTION CAUSED BY AN ATTRACTING MASS.

Let it be required to find the attraction exercised by a given mass placed on the surface of the earth upon a given point on the surface, the distance being supposed so small that the sphericity of the earth need not be considered. Let the position of any point of the attracting mass be determined by the coordinates r, θ, z ; r and θ originating in the attracted point and being measured in the horizontal plane passing through that point, z being measured perpendicular to this plane. Let also the value of $\theta = 0$ correspond to the meridian line, then the volume of an indefinitely small element of the attracting mass being $r d\theta . \ dr . \ dz$, if ρ be its density, its attraction will be

$$\frac{r \cdot \rho dr \cdot d\theta \cdot dz}{z^2 + r^2},$$

and therefore its attraction in the direction of the meridian is equal to this quantity multiplied by $r\cdot(r^2+z^2)^{-\frac{1}{2}}.\cos\theta$; so that the attraction of the whole mass is equal to

$$\iiint \rho\cos\theta d\theta\frac{r^2dr\cdot dz}{(r^2+z^2)^{\frac{3}{2}}}.$$

In order to perform the integrations here indicated, the equation of the surface of the attracting mass is required to determine the limits; this cannot be expressed, nor can ρ, which is also a function of $r\theta z$. But it is easy to find the attraction of a mass of uniform density included within the following surfaces:—The horizontal planes $z=0$, $z=h$, the two cylindrical surfaces defined by the equations $r=r_1$, $r=r_2$, r_1r_2 being constants, and two vertical planes determined by the equations $\theta=\theta_1$, $\theta=\theta_2$, $\theta_1\theta_2$ being constants; ρ being supposed also constant. Integrating between these limits, the attraction of the mass under consideration is found to be

$$\text{A}=\rho h(\sin\theta_2-\sin\theta_1)\log\frac{r_2+\sqrt{r_2^2+h^2}}{r_1+\sqrt{r_1^2+h^2}},$$

which being expanded is equal to (putting $r_1+r_2=2r$)

$$\text{A}=\rho(r_2-r_1)(\sin\theta_2-\sin\theta_1)\frac{h}{\sqrt{r^2+h^2}}\left\{1+\frac{(r_2-r_1)^2}{24}\frac{2r^2-h^2}{(r^2+h^2)^2}+\cdots\right\}.$$

Hence, by taking r_2-r_1 sufficiently small,

$$\text{A}=\rho(r_2-r_1)(\sin\theta^2-\sin\theta_1)\frac{h}{(r^2+h^2)^{\frac{1}{2}}},$$

or if ϵ be the angle of elevation of the centre point of the upper horizontal surface of the mass in question, at the attracted point

$$\text{A}=\rho(r_2-r_1)(\sin\theta_2-\sin\theta_1)\sin\epsilon.$$

If h be small, so that its square may be neglected,

$$\text{A}=\rho(\sin\theta_2)-\sin\theta_1)\left(\log\frac{r_2}{r_1}\right)h.$$

The angle of deflection produced by any horizontal attracting force acting on the plumb-line is measured by the ratio of the attracting force to the force of gravity or the attraction of the earth.

The attraction of the earth upon any point on its surface in latitude λ is*

$$\frac{\text{M}}{b^2}\left(1-e-\frac{3m}{2}+\left(\frac{5m}{2}-e\right)\sin^2\lambda\right),$$

where b is the polar semiaxis, e the ellipticity of the surface, and m the ratio of the centrifugal force at the equator to the equatorial gravity; if we put a for the radius of the equator, the attraction may also be expressed thus—

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* Airy's Mathematical Tracts, pp. 167, 173.

$$\frac{\mathrm{M}}{ab}\left(1-\frac{3m}{2}+\left(\frac{5m}{2}-e\right)\sin^2\lambda\right);$$

here $m=\frac{1}{289}$, $e=\frac{1}{300}$, $\sin^2\lambda=\frac{69}{100}$ nearly; whence it will follow that the term within the bracket will only influence the attraction by less than a six-hundredth part of its amount, and will therefore only affect the calculated deflection in that ratio. Therefore it is sufficiently exact to assume the attraction equal to that of a sphere whose radius is equal to the mean of the principal semi-diameters of the earth, or 3956·1 miles: hence the attraction on any point on its surface $=\frac{4}{3}\pi.\delta\,(3956\cdot1)$, taking the mile as the unit of measure linear. The *deflection*, therefore (expressed in seconds), caused by any attracting force A on the surface of the earth, may be taken as

$$\frac{\mathrm{A}}{\frac{4}{3}\pi.\rho.(3956\cdot1)\sin 1''}=\frac{\mathrm{A}}{\delta}\times 12''\cdot447,$$

δ being the mean density of the earth. Consequently the deflection caused by such a mass as we have been considering at the origin of the coordinates or attracted point, is

$$\mathrm{D}\frac{\rho}{\delta}(r_2-r_1)\,s\sin\epsilon+12''\cdot447,$$

or

$$\mathrm{D}=\frac{\rho}{\delta}sh\log\frac{r_2}{r_1}\times 12''\cdot447,$$

where s is put for the difference of the sines.

The calculation of the attraction or deflection of the plumb-line at any point of the hill is easily effected by means of these formulæ. If through any one of the stations observed from, we draw on a contoured plan of the hill and surrounding country, a number of lines the sines of whose azimuth are successively $0, \frac{1}{12}, \frac{2}{12} \ldots\ldots \frac{11}{12}, \frac{12}{12}$, counting from the south meridian in either direction, and from the north meridian in either direction; and draw also a number of circles whose radii are 500, 1000, 1500, 2000 .... feet, being in arithmetical progression with a common difference of 500 feet; the hill will be thus divided into a number of prisms, the deflection caused by any one of which will be, putting x for the unknown ratio of the density of the hill to the density of the earth,

$$\mathrm{D}=x\frac{500}{5280}\times 12''\cdot447\times\frac{1}{12}\sin\epsilon,$$

so that the total deflection is equal to

$$0''\cdot0982\,\Sigma(\sin\epsilon)\,x.$$

At each of the three stations, the first ring of 500 feet was subdivided by rings at the distance of 100 feet; the result is shown in the following Table:—

SOUTH STATION.

Sums of Sines.	1st Ring, 100 feet.	2nd Ring, 200 feet.	3rd Ring, 300 feet.	4th Ring, 400 feet.	5th Ring, 500 feet
$\Sigma(\sin\epsilon)$ for Prisms South of station	−1·796	−11·294	−11·808	−11·360	−10·001
$\Sigma(\sin\epsilon)$ for Prisms North of station	+1·689	+ 5·448	+ 7·705	+ 9·038	+ 8·845

$\Sigma(\sin\epsilon)=78{\cdot}984$ Deflect North.

ARTHUR'S SEAT.

$\Sigma(\sin\epsilon)$ for Prisms North of station	−7·118	−11·281	−11·845	−12·014	−11·719
$\Sigma(\sin\epsilon)$ for Prisms South of station	−3·524	− 9·164	− 8·603	− 7·436	− 6·421

$\Sigma(\sin\epsilon)=18{\cdot}829$ Deflect South.

NORTH STATION.

$\Sigma(\sin\epsilon)$ for Prisms South of station	+4·867	+4·347	+3·159	+2·179	+1·932
$\Sigma(\sin\epsilon)$ for Prisms North of station	−2·002	−8·038	−8·856	−8 424	−6·973

$\Sigma(\sin\epsilon)=50{\cdot}777$ Deflect South.

By drawing twelve rings at 500 feet apart round the centre station, and sixteen rings round each of the other two stations, the results contained in the following Table are obtained:—

Stations.	Σ $(\sin\epsilon)$.	2nd Ring.	3rd Ring.	4th Ring.	5th Ring.	6th Ring.	7th Ring.	8th Ring.
South Station.	Σ_n	+ 6·614	+3·187	+1·088	+0·025	−0·095	−0·088	−0·418
	Σ_s	− 6·299	−3·531	−2·536	−2·026	−1·713	−1·488	− 1·309
Arthur's Seat.	Σ_n	− 10·560	−7·996	−5·850	−4·656	−4·474	−4·570	−4·209
	Σ_s	− 5·148	−6·634	−7·715	−6·425	−5·295	−4·549	−3·994
North Station.	Σ_n	− 4·644	−3·094	−2·859	−2·361	−1·954	−1·623	−1·422
	Σ_s	+ 2·009	+1·695	+0·978	+1·028	+1·195	+0·745	−0·361

Stations.	Σ $(\sin\epsilon)$	9th Ring.	10th Ring.	11th Ring.	12th Ring.	13th Ring.	14th Ring.	15th Ring.	16th Ring.
South Station.	Σ_n	−0·926	−1·004	−1·037	−1·004	−0·908	−0·843	−0·828	−0·806
	Σ_s	−1·149	−0·985	−0·844	−0·729	−0·625	0·539	−0·472	−0·434
Arthur's Seat.	Σ_n	−3·839	−3·467	− 3.119	−2·883				
	Σ	−3·587	− 3·234	−2·931	−2·667				
North Station.	Σ_n	−1·258	−1·176	−1·117	−1·048	−0·996	−0.941	−0·935	−0·894
	Σ_s	−0·747	−0·671	−0·604	−0·575	−0·558	−0·525	−0·488	−0·449

where Σ_n signifies Σ (sin ϵ) for the prisms north of the station,

Σ_s signifies Σ (sin ϵ) for the prisms north of the station.

Hence we obtain—

South Station.	Arthur's Seat.	North Station.
$\Sigma_n - \Sigma_s = +27\cdot636$	$\Sigma_s - \Sigma_n = +3\cdot441$	$\Sigma_s - \Sigma_n = +28\cdot994.$

In order to obtain the whole effect at each station, we must add to these the fifth part of the sum of the sines in the first ring of 500 feet at each of these stations: these are, respectively, 15·797, 3·766, 10·155; so that we have—

At South Station . . . $\Sigma(\sin\epsilon) = 43\cdot433$
At Arthur's Seat . . . $\Sigma(\sin\epsilon) = 7\cdot207$
At North Station . . . $\Sigma(\sin\epsilon) = 39\cdot149$

Consequently,

Deflection at South Station $= 4''\cdot265\,x$ North
Deflection at Arthur's Seat $= 0''\cdot708\,x$ South
Deflection at North Station $= 3''\cdot845\,x$ South.

Comparison of observed and calculated Deflection.

We may now determine a value of x by the comparison of the observed effects of the action of the hill upon the amplitudes, with the calculated effects in terms of x. The equations thus obtained are

$$4\cdot973\,x = 2\cdot81$$
$$8\cdot110\,x = 4\cdot07,$$

whence

$$90\cdot503\,x = 46\;982$$
$$x = \cdot5191.$$

This solution contains tacitly the assumption that the effect of the *general* south deflection is equal at each of the three stations; if we put y for this quantity expressed in seconds, then the following equations will result from the comparison of the observed and geodetical latitudes, together with the calculated but unknown deflections in x,

$$y - 4\cdot265\,x - 2\cdot44 = 0$$
$$y + 0\cdot708\,x - 5\cdot25 = 0$$
$$y + 3\cdot845\,x - 6\cdot51 = 0,$$

which give $y = 4''\cdot68$ and $x = \cdot5076$.

These quantities give, when supplied in the equations, the following errors:

$$+0''\cdot08;\quad -0''\cdot21;\quad +0''\cdot13;$$

so nearly are the observations represented by these values of x and y.

Extension of the Calculation of Deflection.

The result just obtained, namely, that the ratio of the density of Arthur's Seat to the mean density of the earth is equal to ·5076, is somewhat arbitrary, from this cause, that it is slightly dependent on the extent to which the calculation of the attraction is carried out. Had there not existed a marked difference in the mean height of the ground on the north side and on the south side of the hill, a smaller number of circles would have been sufficient. The existence of this attracting mass forbids our limiting the calculation to the visible extent of the hill; we must, therefore, in order to compare with what we have already obtained, extend the calculation to include a circle of about nine miles in diameter round each station.

We shall now, instead of drawing the circles at 500 feet apart, make the radius of the $n+1$)th circle equal to $\frac{7}{6}$ of the radius of the nth circle, so that they shall be in geometric progression. We have already drawn twelve circles round Arthur's Seat;

the radius of the 13th circle will therefore be $\frac{7}{6}\cdot 500\cdot 12=(\frac{7}{6})\ 6000$ feet, that of the 14th will be $(\frac{7}{6})^2\ 6000$ feet and so on. Around each of the two other stations sixteen circles have been drawn, the radii of the 17th and 18th will therefore be $(\frac{7}{6})\cdot 8000$ and $(\frac{7}{6})^2\cdot 8000$ feet, and so on.

Now if h be the height in feet of any one of the compartments thus formed, we have shown that the resulting deflection in seconds is

$$x\cdot\frac{h}{12}\log_e(\tfrac{7}{6})\ 12\cdot 447\ \frac{1}{5280}$$

$$=0\cdot 00003027xh.$$

The following Table contains the sums of the heights of the surface for each of the additional rings:—

Station	Σ(h)	17th.	18th.	19th.	20th.	21st.	22nd.	23rd.	Total.
South Station	Σ(h) north	+2385	+1685	+ 935	+ 630	+ 465	+ 180	−10	+ 6270
	Σ(h) south	+6060	+6870	+8295	+9010	+8925	+8175	+ 10060	+57935
North Station	Σ(h) north	+ 520	+ 385	+ 277	−15	− 200	− 320	−375	+272
	Σ(h) south	+4495	+5045	+5640	+6475	+8000	+8175	+ 8135	+45965

		13th.	14th.	15th.	16th.	17th.	18th.	19th.	20th.	21st	Total.
Arthur's Seat.	Σ(h)north	+2643	+2245	+1624	+ 904	+ 548	+ 427	+ 148	−92	− 132	+ 8315
	Σ(h)south	+4645	+2025	+5460	+6080	+7460	+8485	+8845	+8550	+9595	+64125

Consequently the effective sums of the heights are,

South Station . . .	$\Sigma(h)=51665$
Arthur's Seat . . .	$\Sigma(h)=55810$
North Station . . .	$\Sigma(h)=45693$

And therefore, multiplying by $\cdot 00003027x$, the resulting deflections are,

South Station	$1\cdot 565\ x$
Arthur's Seat	$1\cdot 691\ x$
North Station	$1\cdot 393\ x$

We see from this that the assumption of y being constant for the three stations was not very erroneous, though the difference is perceptible.

We shall now form the equations for x and y, remarking that y is not now the same quantity that was before represented by that symbol, and that the assumption of its being constant for the three stations is now almost unobjectionable. Taking into consideration the deflections before obtained, the total deflections *south* at each of the stations will be—

South Station . . .	$(1\cdot 565-4\cdot 265)x=-2\cdot 700x$
Arthur's Seat . . .	$(0\cdot 708+1\cdot 691)x=\ 2\cdot 399x$
North Station . . .	$(3\cdot 845+1\cdot 393)x=\ 5\cdot 238x$

Hence the equations are—

$$y-2\cdot700x-2\cdot44=0$$
$$y+2\cdot399x-5\cdot25=0$$
$$y+5\cdot238x-6\cdot51=0$$

which give for the most probable values of x and y,

$$x=\cdot5173 \qquad y=3\cdot8820.$$

By substituting these values in the equations, they show the errors

$$+0''\cdot04; \qquad -0''\cdot13; \qquad +0''\cdot08,$$

showing that the above values agree very well with the observations. From a comparison of the errors of these equations with those previously solved, it would appear that the probable error of this value of x is considerably less than that of the value (·5076) then obtained. The two values, however, are as close as could be expected. We shall adopt, therefore, as most probable, so far as resulting from these observations,

$$x=\cdot5173.$$

We may estimate the probable error of this quantity dependent upon the probable errors of the observed amplitudes thus; writing the three equations in the form

$$y+ax+a'=0$$
$$y+bx+b'=0$$
$$y+cx+c'=0,$$

we have
$$x=-\frac{(a-b)(a'-b')+(b-c)(b'-c')+(c-a)(c'-a')}{(a-b)^2+(b-c)^2+(c-a)^2}.$$

If now λ be the observed latitude of the South station, λ_1, λ_2, λ_3 the geodetic latitudes of the three stations—

$$a'=\lambda-\lambda_1 \quad b'=\lambda+\phi_1-\lambda_2 \quad c'=\lambda+\phi_1+\phi_2-\lambda_3$$
$$a'-b'=\lambda_2-\lambda_1-\phi_1$$
$$b'-c'=\lambda_3-\lambda_2-\phi_2$$
$$c'-a'=\lambda_1-\lambda_3+\phi_1+\phi_2.$$

The probable error of x depends on the probable error of $a'-b'$, $b'-c'$, and $c'-a'$, that is, supposing the geodetic amplitudes to be free of error, on the probable errors of ϕ_1 and ϕ_2. The part of x involving ϕ_1 and ϕ_2 is $\frac{1}{97\cdot07}\times(13\cdot037\,\phi_1+11\cdot070\phi_2)$: consequently the probable error of x is equal to the probable error of $\cdot1343\,(\phi_1+0\cdot85\,\phi_2)$, which by means of the expression given for the probable error of $\phi_1+\mu\phi_2$, becomes (making $\mu=0\cdot85$)

$$\text{probable error of } x=\pm0\cdot0053.$$

Mean Density of the Earth.

Having now ascertained the *ratio* of the mean density of Arthur's Seat to the mean density of the earth, the knowledge of the latter results immediately from the knowledge of the former. Assuming as the result of observation 2·75 for the mean density of Arthur's Seat, it follows that

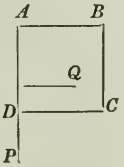
$$\text{Mean density of earth}=\frac{2\cdot75}{\cdot5173}=5\cdot316.$$

The probable error of the divisor ·5173 being ·0053, the probable error of the resulting mean density is ±·054, so that, considering no other cause of error than those of the zenith sector observations, we have

$$\text{Mean density of earth}=5\cdot316\pm\cdot054.$$

The General Deflection.

We proceed now to examine into the question of the sufficiency of the cause before mentioned, namely, the defect of matter to the north of Edinburgh and the accumulation of matter to the south, to produce the general deflection that is observed to the amount of 5″, or rather more. In the first place, let it be required to find the attraction of a rectangular film ABCD, whose thickness is h and density ρ, upon a point P in the production of one of its sides, AD. Measure x along PA, and y perpendicular to it, in the plane of the rectangle, then the mass of a small element is $\rho h dx dy$, and therefore its attraction in the direction AP is



$$\frac{\rho h x dx dy}{(x^2+y^2)^{\frac{3}{2}}};$$

the integral with respect to x between the limits aa' is

$$\rho h \left\{ \frac{dy}{(a^2+y^2)^{\frac{1}{2}}} - \frac{dy}{(a'^2+y')^{\frac{1}{2}}}, \right\}$$

which being integrated from $y=0$ to $y=b$, is

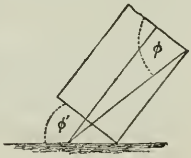
$$\rho h \log_e \frac{\frac{y}{a}+\sqrt{1+\left(\frac{y}{a}\right)^2}}{\frac{y}{a'}+\sqrt{1+\left(\frac{y}{a}\right)}}:$$

If now we put the angles DCP$=\phi$, ABP$=\phi'$, we shall get, since

$$\frac{y}{a}=\cot\phi \quad \frac{y}{a'}=\cot\phi,$$

$$\text{Attraction} = \rho h \log_e \left(\frac{\cot\frac{1}{2}\phi}{\cot\frac{1}{2}\phi'}\right).$$

We may thus determine a sufficiently close approximation to the effect of the hollow of the Forth. An examination of a map of Scotland, on a sufficiently large scale, will show that a rectangle of eighteen miles by twelve, having its longest side inclined 40° the meridian, may be placed so as to cover the greater part of the Forth with some exactness, having also Edinburgh opposite to the middle point of the south side and Arthur's Seat nearly two miles from this side, as in the accompanying diagram. The angles ϕ and ϕ' will be found to be 73° and 18°, and therefore the attraction of a rectangular stratum of these dimensions with thickness h and density ρ will be, (2·3025 being the reciprocal of the modulus of the common system of logarithms)



$$=2\rho \frac{h}{5280}(2{\cdot}3025)\log\frac{\cot 9^\circ}{\cot(36^\circ\ 30')}$$

$$=2\rho h \frac{2{\cdot}3025 \times {\cdot}6695}{5280},$$

and therefore the corresponding or resulting deflection is

$$2\frac{2{\cdot}3025 \times {\cdot}6695 \times 12{\cdot}44{\cdot}7}{5280}\frac{\rho}{\delta}h=0''.00727\frac{\rho}{\delta}$$

in seconds, h to be expressed in feet, δ the mean density of the earth.

An inspection of a chart of the Forth will show that the depth may be taken at a very even average of 30 feet below mean water-level; so that the attraction of the water ($\rho = 1$) upon Arthur's Seat causes a deflection $= 0''\cdot04$ to the north-east at mean water; the latitude of points in the neighbourhood is consequently variable to the amount of about $0''\cdot02$, depending on the tide.

We may now suppose the water to be removed and the hollow filled up with rock to a mean level of 70 feet. Then taking 2·5 for the mean density of the rock, the attraction of this stratum would be $0''\cdot36$, or resolved in the direction of the meridian, the deflection north would be $0''\cdot28$. If the hollow were filled up to a mean level of 150 feet, the deflection north would be $0''\cdot50$.

From this we conclude that the existence of the hollow of the Forth will account for but a small portion of the deflection of $5''$.

To the south of Edinburgh the country gradually rises, until at the southern boundary of the county the mean level is about 1000 feet with peaks rising to 1750 feet. The contours for the county of Peebles are not yet sufficiently advanced to permit the calculation of the attraction of the hills in the north of that county. We may however extend the calculation to the southern borders of Edinburghshire.

The number of circles already drawn round Arthur's Seat is 21, the last nine being drawn according to the law $r_{n+1} = \frac{7}{6} r_n$: if we draw seven more according to the same law, this will carry us slightly beyond the boundary of the county. The sums of the heights in the different rings will then be as follows:—

22nd.	23rd.	24th.	25th.	26th.	27th.	28th.
11850	12050	12850	15950	17100	18750	16800

the sum of which is 105350. The consequent deflection will be, using the same value of x, namely ·5173,

$$0''\cdot00003027 \times 105350 \times \cdot5173 = 1''\cdot64.$$

To this we have to add the quantity obtained for the preceding nine rings, namely $1''\cdot69x$ or $0''\cdot88$, making altogether $2''\cdot52$ due to the high ground to the south within the county of Edinburgh.

From the height of the country in the north of Peebleshire, it seems probable that when the calculation can be carried into that county, a sensible addition to the quantity above determined will be obtained, and that the whole of the $5''$ may *possibly* be accounted for.

In conclusion, the principal results arrived at are these:—

1st. The effect of the attraction of the Pentland Hills is observed in nearly equal amount at each of the three stations on Arthur's Seat.

2nd. The calculated attractions of the mass of Arthur's Seat at the three stations are,—

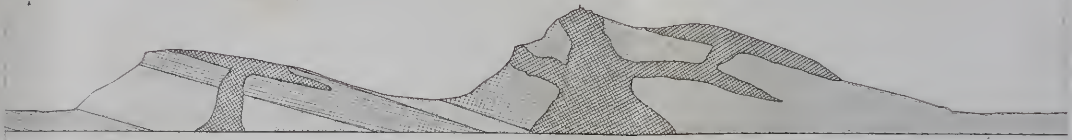
South Station.	Arthur's Seat.	North Station.
$2''\cdot21$ North.	$0''\cdot37$ South.	$2''\cdot00$ South.

and, since the observed deflection at Arthur's Seat is $5''\cdot25$, the apparent effect of the Pentlands is $4''\cdot88$ at the summit of the hill.

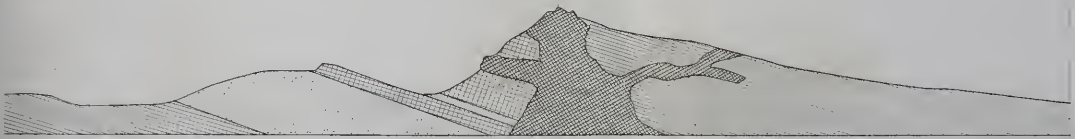
SECTIONS THROUGH ARTHUR'S SEAT

▨ *Trap Rock*

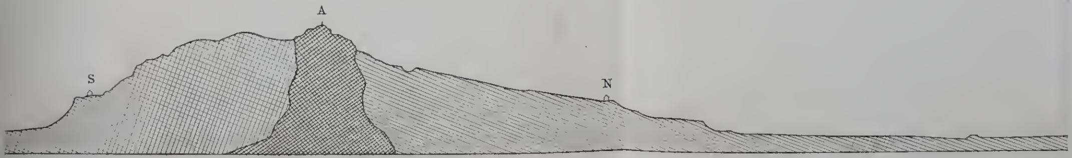
⬚ *Sandstone*



Section on the Line A.B.



Section on the Line C.D.



Section on the Line E.F.

Table of the Specific Gravities of the Rocks in Arthur's Seat

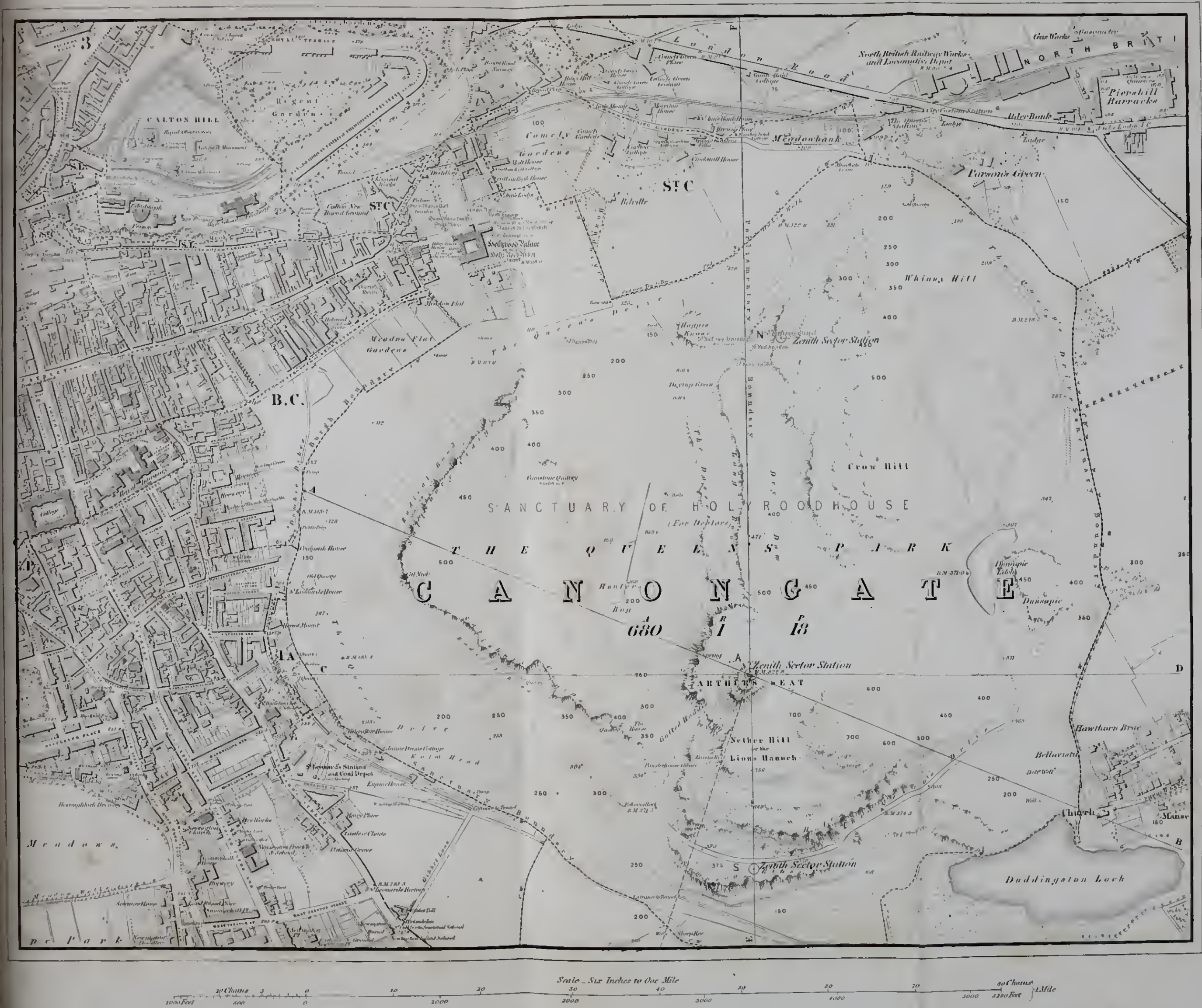
Nº 1 Trap tuff	2.577	Nº 6 Porphyry	2.679
2 Trap conglomerate	3.000	7 Greenstone (Salisbury Craigs)	2.689
3 Amygdaloidal trap	2.663	8 Dº very Compact	2.836
4 Basalt (S^{t} Anthony's)	2.830	9 Sandstone	2.676
5 Basalt under apex	2.698	10 Dº	2.454
		Mean	2.710

2.75 to be used as the Mean in the Computations

PLAN OF ARTHUR'S SEAT

Part of an Electrotype Copy of Sheet 2

EDINBURGHSHIRE



Engraved at the Ord Map Office, Southampton.

3rd. Of this deflection of $4''\cdot88$, the computed attraction due to the configuration of the ground within a radius of fifteen miles accounts for about $2''\cdot5$; and, inasmuch as we know that the igneous rocks of Arthur's Seat and the Pentland Hills have an origin at a great depth below the surface of the earth, the difference between the observed and computed attraction is probably owing in part to the high specific gravity of the mass of rock beneath them.

4th. The deflection of the Royal Observatory, Calton Hill, being $5''\cdot63$ South, exceeds that at Arthur's Seat by $0''\cdot70$. Of this deflection, $0''\cdot60$ is due to the configuration of the ground comprised within a circle of a mile and a quarter round the Observatory.

5th. The latitude of Arthur's Seat or points in the neighbourhood varies to the amount of about $0''\cdot02$ between high and low water.

6th. The mean density of the earth determined from the observations at the three stations on Arthur's Seat, is 5·316, with a probable error of $\pm .054$ (or one hundredth part) due to the probable errors of the astronomical amplitudes. If δ be the probable error of the assumed mean density of Arthur's Seat, the probable error of this determination of the mean density of the earth is

$$\pm\sqrt{3\cdot725\,\delta^2+\cdot003.}$$

REMARKS.

In the original paper as read at the Meeting of the Royal Society on 21st February, the mean density was given as 5·14 with a probable error of $\pm\cdot07$. In a subsequent revision of the calculations, the astronomical amplitudes and their probable errors were determined as herein explained. These amplitudes exceed those previously used by $0''\cdot02$, $0''\cdot01$, 0·03, tending to increase the density. The attraction due to the ground within 100 feet round each of the stations, originally omitted, is now included, also tending to increase the density.

EXPLANATION OF THE PLATES.

PLATE XXXII.

Is the contoured plan of Arthur's Seat, on the scale of six inches to a mile: this is part of one of the sheets of the plan of Edinburghshire which has been published on that scale. The zenith sector stations and the lines of sections are marked on this plan. The contours furnish sufficient data to make a model.

PLATE XXXIII.

Contains geological sections taken on the three lines which are drawn on the plan, and also a table of the specific gravity of the rocks.

These plates have been engraved and electrotyped at the Ordnance Survey Office, and form part of the series of plates made to illustrate the account of the Trigonometrical Survey of Great Britain which is now in the press.

PAPER XV.

ACCOUNT OF EXPERIMENTS MADE WITH THE ROYAL ENGINEER "LANCASTER" RIFLED CARBINE.

BY LIEUTENANT C. E. WEBBER, R.E.

The following are the results obtained by firing with the Lancaster rifled carbine of the Royal Engineers, showing the penetration of the elongated bullet into oak, deal, &c., at various ranges. The Regulation ammunition (the same as for the rifled musket of 1853) was used throughout.

No. 1.—PENETRATION INTO 6-INCH SOUND YELLOW DEAL, CONSISTING OF TWO THICKNESSES OF 3-INCH PLANK CROSSING EACH OTHER, AND SECURED BY STRONG TRENAILS.

RANGE 120 YARDS.

No. of Round.	Penetration.	REMARKS.
No. 1	6 inches.	Penetrated ½ inch into deal prop behind
„ 2	5·32 „	
„ 3	5·31 „	
„ 4	4·06 „	

Giving the greatest depth. 6·5 inches.
„ Mean depth. . 5·3 „

RANGE 420 YARDS.

No. of Round.	Penetration.
No. 1	3·93 inches
„ 2	4·06 „
„ 3	4·9 „

Giving the greatest depth. 4·9 inches.
„ Mean depth. . 4·22 „

No. 2.—PENETRATION INTO 3-INCH IRISH OAK.—RANGE 120 YARDS.

No. of Round.	Penetration.	REMARKS.
No. 1	2·94 inches	Splintered the oak on farther side without passing completely through.
„ 2	2·45 „	
„ 3	2·44 „	
„ 4	2·89 „	The same as No. 1.

Greatest depth.	2·94 inches.
Mean do.	2·68 „

No. 3.—The rifle was fired at 6-inch seasoned oak, at a range of 40 yards: in no case did the bullet penetrate beyond 2·5 inches: the wood was placed so that the ball would *cut the grain transversely.*

No. 4.—The experiment was repeated, the oak being placed so that the bullet should penetrate *in a line parallel to the grain,* and at each round it penetrated 5·1 inches.

No. 5.—The 6-inch deal target was placed so as to float vertically in water, being kept in its position by means of anchors, but was not fixed firmly. It was fired at with a horizontal range of 11 yards. The table below shows the penetration of the bullets, striking the water at various distances from the target.

No. of Round.	Distance from target of point of impact on surface of water.	Angle of depression of rifle.	Depth below water line where ball struck target.	Penetration.
No. 1	2 feet 6 inches	10° 50′	2 inches	·75 inches
„ 2	3 „	11° 5′	3·5 „	1·5 „
„ 3	2 „	10° 40′	2·25 „	1·3 „
„ 4	7 „	12° 40′	4·5 „	·25 „

PENETRATION INTO WOOD COVERED WITH IRON.

No. 6.—A shutter (commonly called a musket-proof shutter) of 1½ inch deal, covered with sheet iron (1½ lbs. to the square foot), was placed in front of a 6-inch deal target. The bullets passed through the shutter and penetrated as below into the deal behind it.

RANGE 420 YARDS.

No. of Round.	Penetration.
No. 1	2·2 inches.
„ 2	4·25 „

No. 7.—A piece of $\frac{3}{16}$ inch plate-iron was clamped in close contact with the 6-inch deal target. All the bullets passed through the iron, and the table shows the penetration into the deal.

RANGE 120 YARDS.

No. of Round.	Penetration.
No. 1	1·06 inches.
„ 2	1·17 „
„ 3	·81 „
„ 4	1· 3 „

Extreme depth.	1·3 inch.
Mean do.	1·08 „

No. 8.—3-inch oak was substituted for the 6-inch deal used in the experiment No. 7.

RANGE 120 YARDS.

No. of Round.	REMARKS.		
No. 1	Passed through iron and penetrated oak 0·3 of an inch.		
„ 2	Do.	do.	do.
„ 3	Made aperture in the iron, the bullet remaining in the metal.		
„ 4	Do.	do.	do.

C. E. WEBBER, Lieutenant, R.E.

Enniskillen, 3rd March, 1857.

PAPER XVI.

NOTES ON EXPLODING CHARGES BY MEANS OF THE VOLTAIC BATTERY.

BY CAPTAIN H. SCOTT, R.E.

In using the Voltaic Battery to explode charges of gunpowder, men must frequently be employed in giving assistance who are unpractised in its use, and who may by their ignorance occasion serious accidents. It is of importance therefore that some plan of proceeding should be adopted which will reduce the possibility of their doing mischief to a minimum, and as I believe that the observance of the following rules would effect this, I wish to propose them for insertion in the Professional Papers.

1st. That the conducting wires from the charge terminate in mercury cups, arranged at a distance of some 20 feet from the spot at which the Voltaic Battery is placed.

2nd. That the terminal wires of the battery, being of sufficient length to reach the mercury cups readily (or the ends of the conducting wires if mercury cups be not used) at that distance, remain coiled up in charge of a sentry until the moment approaches at which the explosion is to be made.

3rd. That the officer then uncoil the terminal wires, and do not again allow them to leave his own hands after he has stationed himself near enough to the mercury cups to complete the circuit on the signal being given.

The extra length of the conducting circuit consequent on this arrangement would be immaterial.

HENRY SCOTT.

Chatham, November 17th, 1856.

PAPER XVII.

NOTES ON THE DEFENCE OF SILISTRIA IN 1854.

By C. NASMYTH, MAJOR UNATTACHED.

The town of Silistria, containing a population of about 10,000 inhabitants, is situated on a promontory on the south side of the Danube, immediately above a reach of the river, which is here studded with several low marshy islands. To the south and east the town is commanded by a range of heights, varying from 300 to 800 feet above the level of the river, which terminate the Bulgarian plateau. On the spurs of these hills were erected detached works to which may be mainly attributed the successful defence of the place against the Russian attack in May and June 1854.

The four principal of these have been built upon the prominent points of the hills, at distances of from 600 to 800 yards from the town. The largest, named Medjidiè, has a casemated keep, and lies to the south west of the town; to the west of this work is that called Kutschuk Mustapha, and to the east of it is Urdu Tabia. To the east of the latter and to the south east of the town is Ylanli Tabia, which commands the branch of the river near it for some distance.

Two others are placed upon the low ground on each side of the town, that of Djermen being to the east and Tchâir to the west of it, and each is about 300 yards from it. At the extremities of the north-western line of fronts are the works of Ditsch-Tschengel (about 100 yards distant from the Tschengel bastion), and Liman, at about the same distance from the Mehemdiss bastion.

On the ridge occupied by Ylanli Tabia, and 600 yards to the south of the latter, an earthen advanced work, called Arab Tabia, was also constructed, the form of which is shewn in the plan; it occupied a commanding position, and was armed with 6 field pieces, but was not enclosed at the gorge, nor was its ditch palisaded. Its profile was of the following dimensions:—Width of ditch, 9 feet 10 inches; of berm, 1 foot; of exterior slope, 5 feet; of superior slope, 6 feet; of interior slope of the parapet, 1 foot 6 inches; of tread of the banquette, 4 feet; base of the slope of the banquette, 5 feet; height of crest of the parapet, 6 feet 6 inches; depth of the ditch, 6 feet 9 inches.

All these works, excepting Arab Tabia, were designed by two officers in the Prussian service. From these heights having been unoccupied in 1829, the attack of the Russians (traces of which still remain in rear of fort Medjidiè) was a comparatively easy undertaking. The body of the place consisted of a weak bastioned enceinte traced on an irregular ten sided polygon, and its' armament was about 60 pieces, including mortars. The strength of the Turkish garrison was at this period (May 1854) about 12,000 men of all arms.

Towards the end of 1853 the Russians established themselves on a long island called Pisilla, opposite to the town, and on the north side of one of the arms of the river, as well as on the islands of Hoppa and Schiblak, lower down, and from the batteries placed there harassed the town and the forts of Ditsch-Tschengel and Liman close to the river, both previous to and during the whole siege, so much so that the sick had to be removed from the town and placed under canvass near fort Medjidiè; yet some of the enemy's shot reached them even there.

On the 15th of May, 1854, we received intelligence of the advanced guard of the Turks being repulsed at Bootchook, and of the advance of the Russian force, estimated at 12,000 men, accompanied by eleven chaloupes and a river steamer, from the direction of Rassova, and at about ten o'clock the following morning their advanced guard appeared on the height next but one to the east of Arab Tabia, where they established themselves. The next day they received a considerable accession to their numbers, brought to the Island of Schiblak, over a bridge of boats which had been constructed some time before, and thence to the south side of the river by chaloupes. During the night of the 16th, the enemy commenced his first parallel at a distance of about 2 miles from the body of the place. During the ensuing few days their attack was suspended, but they kept up a severe cannonade on the town and advanced works from the islands, to occupy our attention during the transport of their siege materials, and this cannonade was kept up from daylight till dusk. Subsequently the enemy received reinforcements from Kalarasch, where their headquarters had been established during the winter. In the town we found it necessary to construct large and strong traverses along the eastern face, which was enfiladed by a cavalier counter-battery on the Island of Pisilla, and the Arnout and Albanian trench, extending along the edge of the steep spur of the hill which slopes from Arab Tabia down to Ylanli, was deepened, and the parapet thickened.

During the 17th, 18th, 19th, and 20th, whilst proceeding with the first parallel, the enemy threw a second bridge of boats across the river from the Island of Schiblak to the south side, a little further up than their first one, in which occupation they were considerably annoyed by the guns of Ylanli. On the 20th the enemy commenced his second or rather his first parallel (as the former was merely a preparatory trench at some distance in rear of it, and seemed to have been used simply to afford shelter during the transit of his siege stores from the river to the heights.) During the two following nights he pushed forward his works with vigour, and on the morning of the 22nd the batteries of the first parallel and two on the Island of Salhanè opened fire on Arab and Ylanli Tabias, causing us a loss of upwards of 50 killed and wounded, and considerably damaging the block-house in the latter fort, which however was repaired and thickly covered with sods during the ensuing night. The enemy subsequently erected a 15-gun battery against Arab Tabia, and three additional ones on Salhanè; and in the evening of the same day they opened fire on Arab Tabia and Ylanli. From the dispositions of the enemy we anticipated an assault, which, however, did not take place. This demonstration was repeated on the afternoon of the 25th, and during a tremendous hail storm about seven battalions of the enemy advanced from their extreme left, with the intention, as we supposed, of storming Arab Tabia, but they were checked by the well sustained fire from the Arnouts and Egyptians.

The garrison of Arab Tabia consisted of—

3 Battalions of Arabs, furnished by the Viceroy of Egypt.

1 Battalion of Redif.

1 Company of the newly organized Chasseurs; and about 1,000 Arnouts and Albanians, who occupied a trench communicating from Arab Tabia to Ylanli, and from which, they were in the habit of making sorties frequently, and thereby harassing the enemy and impeding his progress.

On the 26th the enemy was employed in entrenching himself by constructing strong detached earthworks on the heights above Adakieu, and the whole of the wood in the vineyards which skirt the Danube was in process of being cleared away. About 3 A.M.

of the 29th the enemy made a serious attack upon the southern face of Arab Tabia, and so rapidly that part of the storming party actually got inside the work, but they were repulsed with considerable loss. After re-forming, they again attempted it in the same place with a similar result. The attack was made on a larger scale a third time on the whole of the faces of the work, but this also proved abortive, and the now infuriated Albanians pursued the enemy into his own batteries, where they did so much damage to his works as to retard his progress for several days. This success on the part of the defenders contributed in no small degree to inspirit the garrison, although its loss was 65 killed (among whom were a major and two captains of the Egyptians, a lieutenant of the Artillery, and several other officers), with 112 wounded; that of the Russians is difficult to ascertain, as many who had been killed near their batteries were removed before daybreak; however from the number of bodies that filled the ditch in front of the work, and of the arms and accoutrements which were afterwards collected, their loss was calculated to have been about 2,000.

The failure of these assaults may be partly attributed to the fact of the Russians having some young troops, who, the prisoners informed us, had arrived only two or three days previously, and were opposed by some of the best troops in the Turkish army. We learnt from the same source that Prince Paskievitch commanded in person, and that he and two other General Officers were wounded, and two others killed on this occasion, one of whom was General Ochterlony.

A flag of truce was sent out on the morning of the 30th for the purpose of giving over the dead to the Russians for burial. On the evening of the 30th the Russians threatened another attack upon Arab Tabia, but having received such a severe lesson on the morning of the 29th they did not seem to fancy hazarding a repetition of the assault, and retired after a sharp fusillade. Our casualties on this occasion were 7 killed and 10 or 12 wounded.

During the 30th and 31st the enemy were occupied in repairing the works damaged, and on the evening of the latter day they were discovered driving a mine under the eastern angle of Arab Tabia. A retrenchment was thrown up cutting off the angle, and two field pieces, which had been mounted "en barbette" at this angle, were placed behind the new work. Next morning we observed a cavalier counter-battery thrown up on the extreme left of the enemy's trench at about 100 yards from Arab Tabia. The enemy's second parallel was nearly completed about this time, and under cover of the batteries on the islands and a rifle trench on Salhanè, he pushed his approaches against Ylanli with energy.

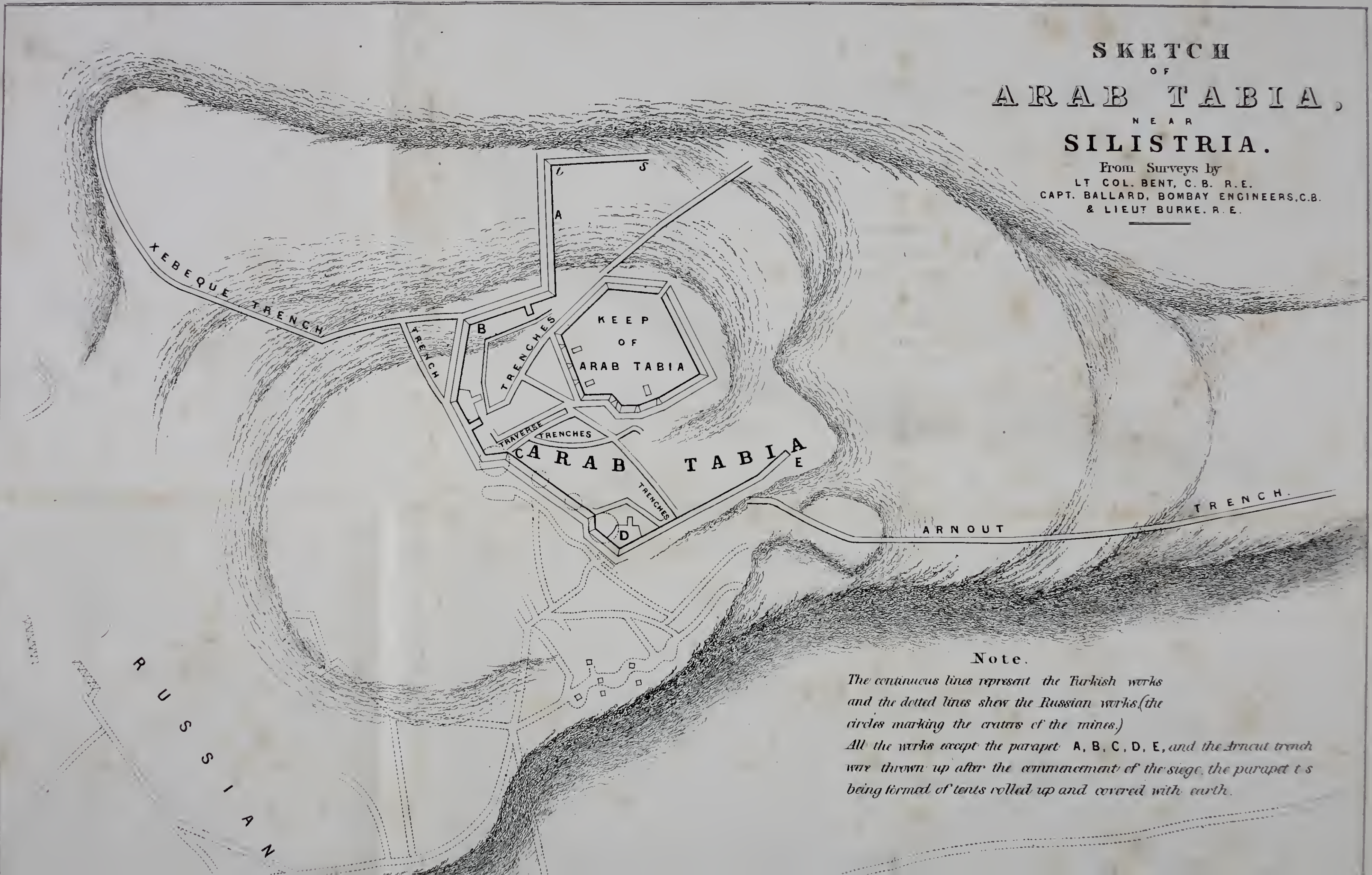
On the 2nd of June, Mussa Pacha, the Commandant of the place, was mortally wounded by the bursting of a shell in the Stamboul gateway, of which he died in ten minutes: his death was a great loss: he was succeeded in the command by Hussein Pacha. In the afternoon of this day we received a reinforcement of 3,000 Albanians and 5,000 Bashi-Bazouks under Mehemet Pacha, who encamped under Fort Medjidiè. At about 5 o'clock, P.M., the enemy fired a mine under Arab Tabia, which, owing to some mismanagement, exploded backwards, doing considerable damage to their own batteries as well as to the head of the storming party. The Albanians, as usual, took advantage of the confusion, and of their own accord sprang in amongst the disordered Russians, who, after effecting as much damage as possible, returned to their trenches. The day following the same mine was again loaded and fired, but owing to the enemy not having calculated on the tenacious nature of the soil (it is presumed) the explosion took effect along the gallery, instead of effecting their purpose: however it shook the parapet so much as to render it advisable to withdraw the troops within the retrenchment already formed, with the exception of a small picquet.

On the 3rd a small mine was sprung, which completely destroyed the eastern demi-bastion. The same evening another mine was discovered to be in progress underneath the right demi-bastion. In consequence of a want both of mining tools and men who could use them, it was impossible to attempt countermining, we therefore formed a second retrenchment extending from the small barbette to the end of the Arnout trench; behind this, under a severe fire kept up during the whole of the night, we succeeded in transporting the guns, ammunition, &c., and during the whole of the 4th and 5th we suffered from nothing but a constant and well directed fire, the enemy remaining within their own works and occupying themselves in pushing forward their approaches towards Forts Ylanli and Djermen. On the night of the 4th or morning of the 5th the new retrenchment was finished, and, though only a make-shift, it answered our purpose in defeating the enemy's object in mining. At about half-past 9 P.M. the mine in question was unsuccessfully fired The third parallel progressed, and a flying sap leading from it towards the northern angle of Ylanli was commenced. On the 6th we discovered that the enemy had constructed a line of detached earthworks considerably in rear of his attack against Arab Tabia, and extending towards the village of Alfatlar. In the afternoon the enemy made a reconnoissance in force on the plain in front of Fort Medjidiè, where he was met by our Cavalry and Bashi-Bazouks; the latter were pursued by a regiment of Lancers, who were only stopped by finding themselves under the guns of Medjidiè and Kutschuk Mustafa. The enemy's cavalry was supported by 18 field pieces and two columns of infantry. Towards sunset the whole of this force retired in the direction of the Deli Ormon. In consequence of this demonstration on the part of the enemy, an extra battalion and a strong detachment from Medjidiè reinforced the garrison of Arab Tabia.

On the morning of the 7th* we were awakened by a salute fired in honour of Rifaut Pacha: he was accompanied by Colonel Simmons, Royal Engineers, Commissioner at the Turkish head-quarters, Captains Ballard and Fearon his assistants, and Captains Gavoné and Crespi, of the Sardinian army.

Under the instructions of Colonel Simmons and Captain Gavoné the last retrenchment, or keep, in Arab Tabia, was traced, which was held till the end of the siege. This measure was adopted in consequence of the severe loss suffered by the garrison of the work (now reduced to about 1,000 men), as well as the extent of the mines which had been driven under the original parapet. By the evening of the 9th this work was completed, and the enemy had finished his third parallel, reaching to within forty yards of the southern angle of Ylanli. On the afternoon of this day a large body of the enemy suddenly appeared before Urdu Tabia, and afterwards extended his line in front of Medjidiè and Kutschuk Mustapha. The enemy's force consisted of ten or twelve Battalions in column, three Regiments of Regular Cavalry, twelve field pieces and a strong body of Cossacks, who after engaging our Bashi Bazouk out-posts above the village of Kalipetri, drove them in upon the Regular Cavalry who were drawn up in front of Fort Medjidiè. After various attempts the Russians succeeded in securing the village of Kalipetri, out of which however the Cossacks were driven towards evening, and the whole of their force, which appeared to have

[Note.—It is here necessary to state that Majors Butler and Nasmyth were the only British officers present in Silistria until the 7th of June. Being there when the siege commenced, they offered their assistance to the Commandant, and their services were acknowledged by the Turks to have been invaluable; indeed, a correspondent of the "Times" states in the number of that journal dated 21st July, 1854, that "had it not been for their energetic remonstrance on the 25th May, the Arab Tabia would have been abandoned."—Ed.]



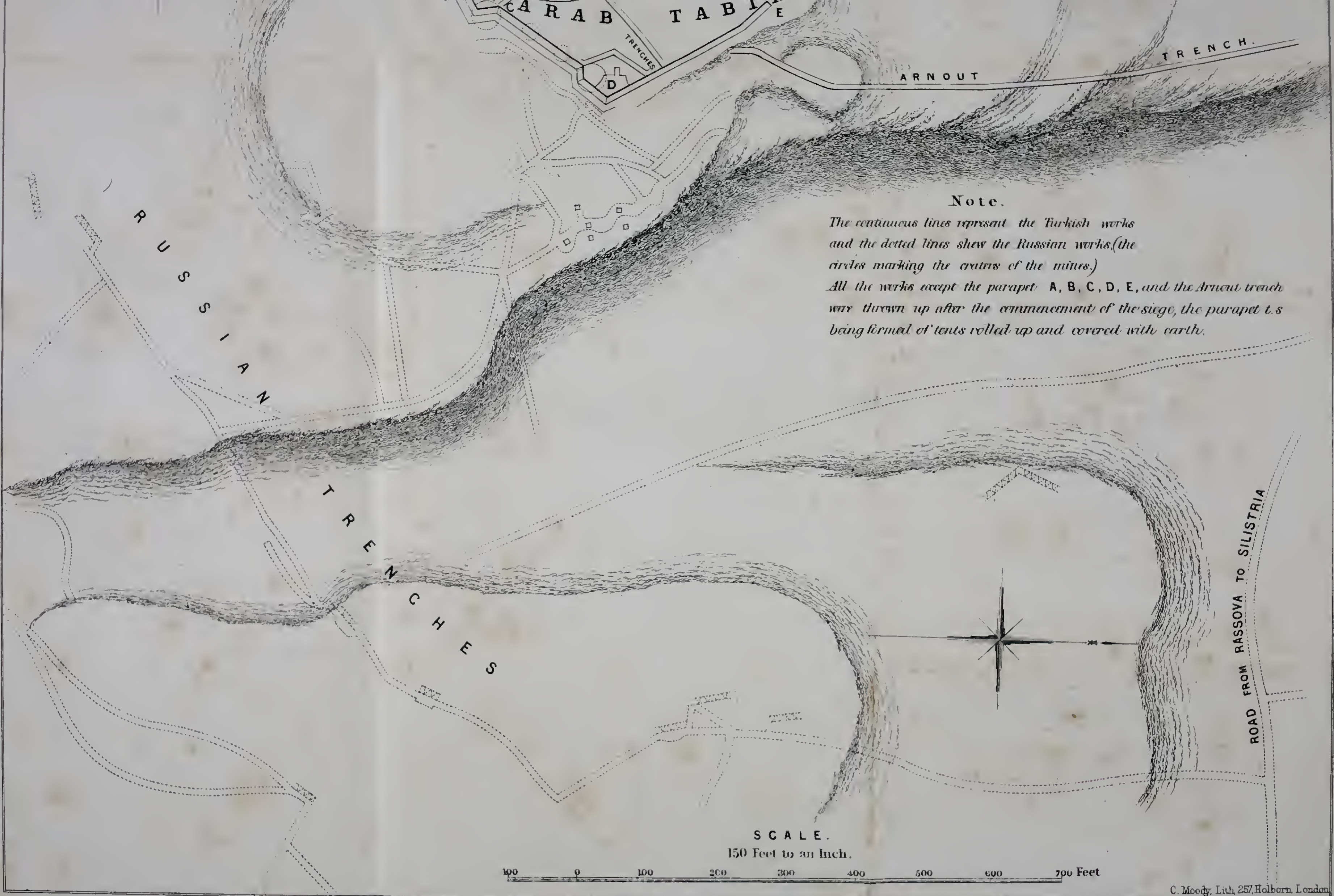
SKETCH
OF
ARAB TABIA,
NEAR
SILISTRIA.

From Surveys by
LT COL. BENT, C.B. R.E.
CAPT. BALLARD, BOMBAY ENGINEERS, C.B.
& LIEUT BURKE. R.E.

Note.

The continuous lines represent the Turkish works and the dotted lines shew the Russian works (the circles marking the craters of the mines.)

All the works except the parapet A, B, C, D, E, *and the Arnout trench were thrown up after the commencement of the siege, the parapets being formed of tents rolled up and covered with earth.*



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C. Moody, Lith, 257, Holborn, London.

been sent to find out the strength of our Cavalry, retired by a long detour towards the south. Our force engaged in this affair consisted of three Regiments of Regular Cavalry and about 800 Bashi Bazouks, the former being supported by six field guns, which, with those of the Medjidiè and Kutschuk Mustapha, did considerable damage to the enemy's Cavalry, who however succeeded in removing all their killed and wounded.

At about 3 o'clock A.M., on the 10th, the enemy fired a mine under the left bastion of Arab Tabia and effected an entrance within the retrenchment made on the 3rd, but, meeting with a heavy fire of grape and musketry from the new retrenchment, were repulsed with loss. Our loss on this occasion was 43 killed and 72 wounded, of whom two of the former and three of the latter were officers. On the 12th another mine was sprung which merely blew in the most southern salient of the work. On the 13th Captain Butler received a mortal wound whilst looking over the parapet at the northern angle of Ylanli, from the effects of which he died on the morning of the 21st.

On the night of the 18th the enemy advanced to Ardemie, a village close to the river, on the Turtukai road, with 4,000 infantry and 2,000 cavalry; and some deserters stated that they had crossed the Danube in force at Turtukai.

On the evening of the 19th, after a comparatively quiet day, the enemy opened a furious cannonade both on the town and advanced works, after having exploded a mine, (his last), under the old parapet of Arab Tabia, which for some time past had been abandoned, forming a breach in the curtain about twelve yards wide. On discovering the new entrenchment the enemy abandoned their intention of assaulting, but kept up an increased musketry fire from their trenches.

On the 22nd, the Russians withdrew from Ardemie, with the view of raising the siege; and on the morning of the 23rd, after a tremendous bombardment, they abandoned their position, leaving the whole of their works, three miles in extent, and of great solidity, in perfect condition. They effected a rapid crossing of the Danube by the two bridges near their position, and by a third about five miles lower down the river, the former being removed by the 25th.

Owing to the strength of the Russians, which was computed at 60,000 men and 60 siege guns, besides field pieces, on the south side of the river, and the constant and fatiguing duties of the Garrison, the enemy's retreat was not harassed or interfered with until the 26th, when a body of 2,000 cavalry and 10 field pieces was sent in pursuit. On reaching the spot where the lowest bridge had been, they found themselves within range of the Russian guns (18-pounders) on board chaloupes, and of a battery on the opposite shore, which caused them, in spite of very indifferent practice, a loss of two men and four horses killed, besides several wounded.

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